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CONTENTS

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OLD PROBLEMS AND A NEW TECHNIQUE[1]

IT is a truism to say that new instruments and new modes of technique may be as productive of advances in science as generalizations that point the way for many investigations. The telescope, the photographic plate and the spectroscope in astronomy, the chromometer and the thermometer in physics, the balance in chemistry, the microscope and the microtome in biology are trite examples of instruments and related technical processes so commonly used that their importance is forgotten. During the past twenty-five years, the string-galvanometer and methods of determining small amounts of gases in blood and other fluids of the body have been productive of great advances in physiology; while instruments for micro-dissection, and methods of staining, like those with hæmatoxylin, have made possible a flood of investigations.[2] The Greeks failed in

[1] Address of the retiring Vice-president and Chairman of Section F, American Association for the Advancement of Science, read at the Zoologists dinner, Nashville, December 29, 1927.

[2] The advent of such methods is sometimes vividly remembered by those who lived through the period. Recalling that I had once heard my former teacher, Professor S. F. Clarke, of Williams College, speak of the coming of ribbon sections in the early eighties of the last century and knowing that two other veteran American Zoologists, E. B. Wilson and E. L. Mark, were students abroad at this period, I inquired of these individuals. Each has contributed items of interest, but the statement by Professor Wilson is the most comprehensive. He says: "I first became acquainted with the ribbon method of section-cutting at the laboratory in Cambridge just after its discovery by Caldwell in 1882, and as I had very recently completed a research which involved the laborious cutting of great numbers of small eggs, one by one, and mounting the sections singly, you can imagine the surprise and pleasure with which I saw them reeled off wholesale by the ribbon method. As it happened I was, I think, the first person to introduce this method in Germany, having taken it over to Leuckart's laboratory in the early winter of the same year, and I have never forgotten the astonishment with which the operation was viewed by the group working there at the time. It was at first employed simply by the old method of cutting by hand with a razor on a flat-topped glass plate secured to a table, and was only a little later extended to the Thoma sliding microtome. It seemed to me then, and still seems to me, to be one of the most important steps

science as much through technical limitations as through their political collapse. In physical science, for example, they lacked accurate and convenient instruments for the recording of time and temperature, but more particularly they lacked methods of computation. One can appreciate the difficulties of such simple arithmetical processes as multiplication and division by Roman numerals, but the technique of the Roman system was less cumbersome than that used by the Greeks. The advent of the Arabic system, with its decimal point and with zero as a "placeholder," marked a new era for the natural sciences as well as for mathematics. I have thus referred to familiar advances of science through instruments and methods, because I believe the biological sciences have now at hand a technique that is not fully appreciated, although its importance has been demonstrated. I refer to the technique of *irradiation*.

The discovery of X-rays by Röntgen (1895) and of radium by the Curies (1898) was soon followed by applications in the medical field to diagnosis of gross features like skeletal fractures, and, when the "selective" action of the rays was discovered, to the treatment of malignant growths. That the more general possibilities in medicine were appreciated by Röntgen is shown by the fact that his original communication was made before a medical society and his first account published in a medical journal. These early applications were marked by sacrifice, since neither the danger to the operator nor the present modes of protection were known at the outset. Sterilization, burns, and even death were the lot of more than one radiologist, and patients no doubt suffered. But the present effectiveness of irradiation in the treatment of certain cancers is worth more than these earlier costs. Subsequent extensions of the method and of X-ray photography in clinical medicine are familiar. No hospital is complete, no physician's or dentist's service adequate unless X-ray diagnosis is available.

In correlation with the initial extensions in medical science, the interest of biologists was aroused, and during the first decade of the century certain general investigations were undertaken. Bohn ('03), Willcock ('04), and others conducted experiments upon the effects of radium and of X-rays in lower organisms. Gager ('08), exposed *Enothera* to radium and obtained changes that resembled mutations. The effects of irradiation upon the tissues and embryos of higher vertebrates were likewise examined in exploratory investigations. The "selective" action of the rays, in destroying certain types of cells, was studied by medical workers, and, later, the "differential" action of different wave-lengths. The existence of a "latent period" between irradiation and tissue changes was established. Within the cell, it was seen that the nucleus, and particularly the chromatin, was most susceptible to radium and to the X-radiations. There was, however, no such extension of radiology in the general biological field as occurred during the second decade of the century in the field of medicine. Interest in other lines, the war, and failure to obtain results that promised returns of general importance were no doubt responsible. While our medical colleagues went forward in the use of the X-rays in diagnosis and therapeutics, if not in research, biologists lagged behind. In like manner, ultra-violet irradiation began to be utilized in medical practice during the second decade of the century, without attaining a corresponding importance in biology.

My own interest in the technique of irradiation was aroused by a renewal of earlier studies upon the cellular changes during regeneration in planarians. In the regeneration of *Planaria maculata*, after reproduction by fission, it had been observed that cells called "formative cells" were the active units. These formative cells have relatively large nuclei and spindle-shaped cell bodies sometimes with extended processes. They divide by mitosis and seem capable of migration through the mesodermal syncytium or parenchyma. At the time of regeneration they are the only important source of new tissue. If my interpretations are correct, they form ectodermal, endodermal and mesodermal cells, nervous tissue, and special organs like eyes and pharynx. Moreover, they give rise to the germ cells when reproductive organs are formed. During the later stages of embryonic development similar cells are abundant in the mesodermal region. It seems, therefore, that the formative cells constitute a "meristem," which is the source of new cells during growth and regeneration, which has descended without modification from similar cells in the embryo, and which is the path of descent for the germ-plasm. These conclusions have been confirmed with minor exceptions by other investigators, and recently checked in *Planaria agilis*, another spe-

in the technique of microscopical anatomy, and especially of embryology. I do not know when the staining of sections on the slide was first introduced, but it certainly was prior, I think, to the discovery of the ribbon method; if I remember rightly it began with the use of shellac as the means of fixing sections to the slide, some time before the invention of the albumen method by Paul Mayer. It might interest you to know that I still have my old series of sections of the Renilla eggs cut singly, I think in 1881, forty-six years ago. I am obliged to confess that, from the modern point of view, they are rotten sections, but it cost blood to make them at the time."

cies with powers of fission and regeneration similar to those of *P. maculata.*

Not all planarians regenerate as effectively as do *Planaria maculata* and *P. agilis.* In returning to the problem of regeneration during recent years, my interest was centered upon the relative abundance of formative cells in different species in relation to their respective powers of regeneration. It is a familiar fact to workers with planarians that some species have almost no power of regeneration. Such planarians are in marked contrast with species like *Planaria maculata* and *P. agilis,* which regenerate rapidly and completely. Other species of planarians have what one may call the "capacity" to regenerate, but only at a slower "rate." One may thus speak of the *power of regeneration* as including *capacity* and *rate.* A species like *Planaria maculata* or *P. agilis* has great capacity and a high rate, while *Dendrocœlum lacteum* has little capacity and a slow rate. *Phagocata gracilis* has the capacity, but the regeneration proceeds at a slower rate than it does in *Planaria agilis* or *P. maculata.*[3] To check these facts of general observation, experiments upon the relative powers of regeneration in these three genera (*Planaria, Phagocata* and *Dendrocœlum*) were undertaken, with results that confirmed what was known from more superficial examination.

With these differences in regenerative power established, the numbers and activities of the formative cells in the non-regenerating species, *Dendrocœlum lacteum,* were examined for comparison with *Planaria maculata* and *P. agilis.* This was done by making counts of these cells in measured areas. Although it was recognized that such counts could not be made without a large margin of error, it seemed that a quantitative statement might thus be obtained that would have more value than general terms like "few" and "many." As a result of such counts it was estimated that *Planaria maculata* possessed about 44 formative cells per unit area, and *Dendrocœlum lacteum* about 9, a difference that is in accordance with the powers of regeneration in the two species. It was therefore possible to make the declaration that the *power of regeneration is correlated with the number of formative cells.* If I may descend to a colloquialism—"show me the formative cells of a planarian and I will tell you approximately its power of regeneration, or show me its power of regeneration and I will tell you the relative numbers of its formative cells." The observations confirmed the conclusions regarding the rôle of formative cells in the regeneration of species like *P. maculata* and *P. agilis,* since it was shown that a species like *Dendrocœlum lacteum* with very few of these cells had scant power of regeneration.

At this point it seemed that confirmations might be obtained by further comparisons between regenerating and non-regenerating species, but that more direct evidence could not be obtained by the methods that had been employed. A more satisfactory test would be to destroy the formative cells and thus transform a planarian capable of regeneration into one incapable of such changes. The formative cells appeared to be undifferentiated and embryonic. If undifferentiated cells could be killed in higher animals by irradiation, it seemed that they might be killed by this means in planarians; and once they were killed it should be impossible for the individual to regenerate. Such experiments were tried with *Planaria agilis* (*cf.* Figs. 1–4). When a sufficient exposure was used (approximately 12 skin-units in clinical terminology) no regeneration occurred, although the worms remained alive without external signs of abnormality in structure or function for some time beyond the twelve-day period during which regeneration was completed in the controls of these experiments. When these irradiated worms were sectioned it was found that the formative cells were so reduced in numbers, if not all destroyed, that there seemed to be none remaining in many of the specimens. The mesodermal region was thus changed from its characteristic appearance in *Planaria agilis* to the appearance seen in *Dendrocœlum lacteum* in which there are few formative cells and in which there is scant power of regeneration. Lesser exposures to X-rays partially checked the regeneration and the numbers of formative cells were noticeably reduced. In an experiment with radium, in which an exposure about equivalent to that with the X-radiations was used, regeneration was inhibited in a similar manner.

Unfortunately, it has not been possible to keep the irradiated worms alive for an extended period. At the end of three weeks, or about one week after regeneration is complete in controls, the X-rayed individuals begin to show abnormalities of structure and function. Death ensues about four weeks after the irradiation. It is hoped that further experiments will give worms which can not regenerate, in which formative cells can not be found, and which can be kept alive in a normal state for longer periods. One could then eliminate the possibility that it is the destruction of something else in the planarian, upon which the formative cells are dependent, that is responsible for the check upon regeneration and that disappearance of the formative cells is merely the

[3] *Phagocata gracilis* is not so favorable for this purpose because of its multiple pharynges, but *Dendrocœlum lacteum* is a perfect illustration of scant power of regeneration as compared with a species like *Planaria maculata.*

Inhibition of Regeneration in Planarians by X-rays and Destruction of Formative Cells

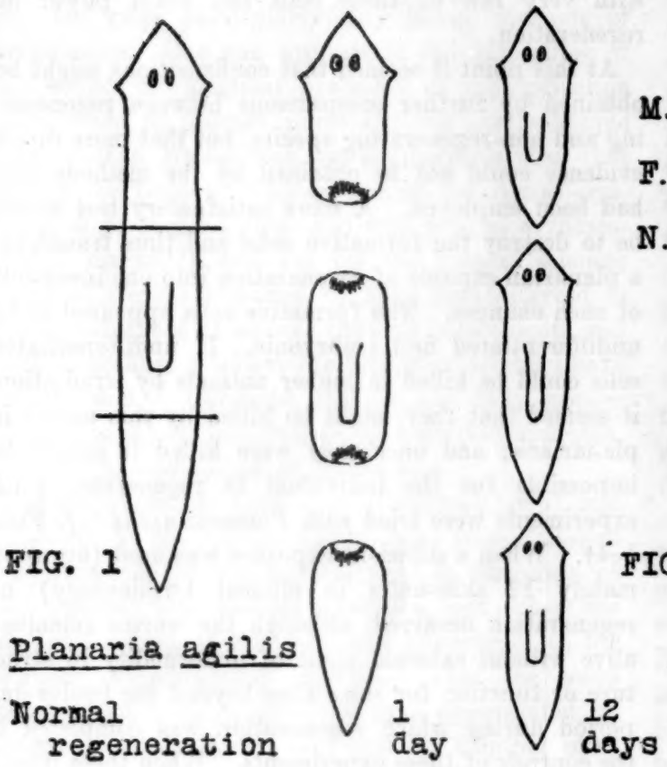

FIG. 1

Planaria agilis

Normal regeneration — 1 day — 12 days

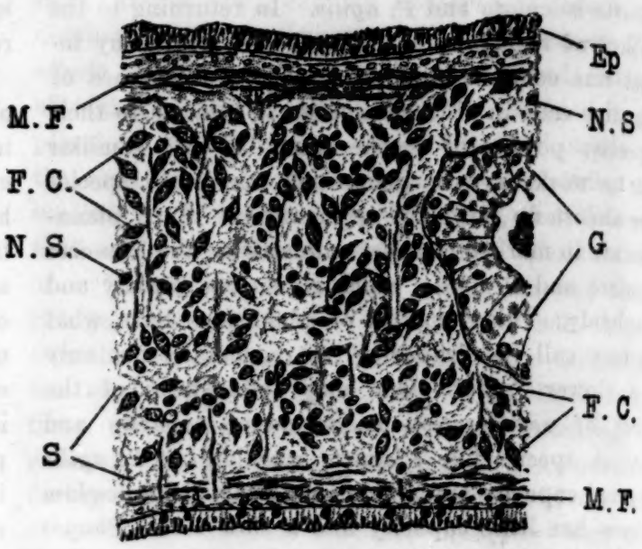

FIG. 3 Planaria agilis

Section showing the numerous formative cells in the mesodermal region of the normal worm

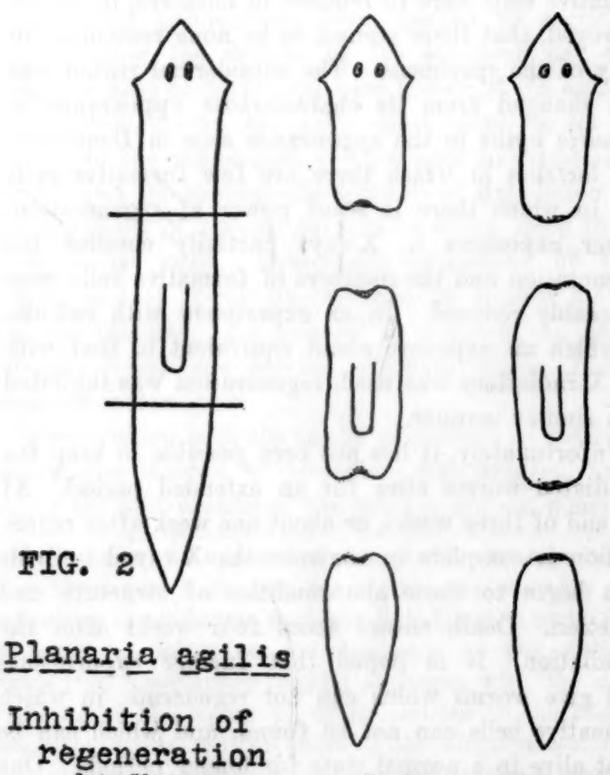

FIG. 2

Planaria agilis

Inhibition of regeneration by X-rays — 1 day — 12 days

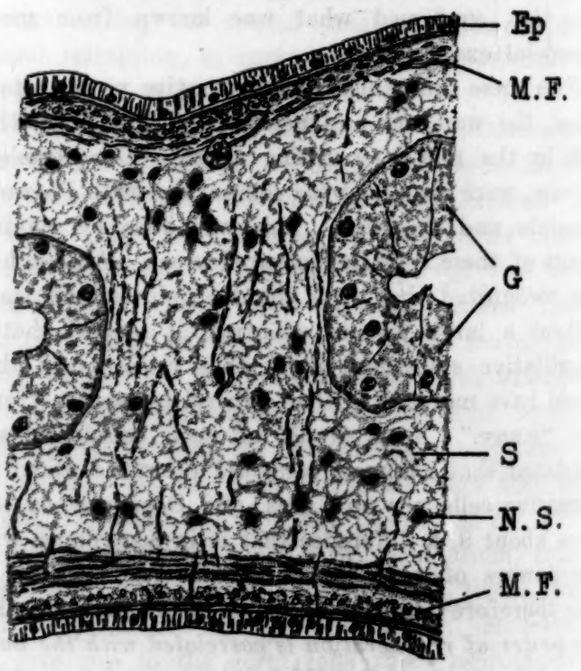

FIG. 4 Planaria agilis

Section showing destruction of formative cells by X-rays. The mesodermal syncytium, with its small, dense nuclei, the gut, and other structures are still normal in appearance

Ep, epithelium; F.C., formative cells; G, branch of gut; M.F., muscle fibers; N.S., nuclei of mesodermal syncytium; S, mesodermal syncytium. (Drawn by Wiley Crawford.)

first step in a series of degenerative changes that end in death of the individual. The formative cells may be the "indicators" and not the ultimate factors in regeneration. In view of our limited knowledge concerning the manner in which radiations produce their effects in protoplasm, this possibility must be considered. If one could secure irradiated planarians that could not regenerate and possessed no formative cells, but lived indefinitely with no other abnormalities in structure or functions, this possibility might be disregarded. According to the hypothesis that the new parts formed during growth and regeneration come only by differentiation of formative cells and that the germ cells of the planarian have a similar origin, such a planarian would be unable to reproduce either sexually or asexually and it would be incapable of growth by increase in the number of its cells. It would be an interesting animal. What would be its expectation of life? Would it exhibit senescence and rejuvenescence, if there are such phenomena in planarians? Would it eventually acquire new formative cells and become capable of regeneration? Would it have an axial gradient? A technique that gave such results would enable us to attack the problem of differentiation as it has not been attacked before.

In testing the formative-cell hypothesis as extended to other animals, experiments with X-rays have been conducted upon sponges and cœlenterates. It has been shown that regeneration can be completely inhibited in the hydroid *Tubularia crocea*, as reported at these meetings. An initial experiment with hydra has been likewise successful. The histological changes involved in these cases among the cœlenterates have not yet been ascertained. The experiments with sponges have not yet given significant results.

Proceeding to other illustrations of applications of the technique of irradiation: Regeneration is an aspect of development. What promise does such a technique hold for students of development in general? That much remains before we shall have reached a satisfactory understanding of ontogeny has been recently set forth in a masterful way by F. R. Lillie ('27), in an essay entitled "The Gene and the Ontogenetic Process." In speaking of the process of embryonic segregation, Lillie says: "We have no present working hypothesis of this most fundamental aspect of the life history." Workers in embryology, therefore, admit that they have reached a point of "diminishing returns" by sectioning and staining, by microdissection, and that even the talisman of physicochemical explanation has failed in its older methods. New technical methods are needed to carry us much farther and enable us to formulate new hypotheses.

There has been, as yet, no great progress, although enough has been accomplished to show possibilities by the technique of irradiation. Working with the ultra-violet radiations, Just has produced Nereis larvæ with nuclei that contain 70 chromosomes instead of the normal 28. Here the maturation divisions go on without polar-body formation so that the sperm nucleus unites with four egg nuclei instead of with one; each egg nucleus as well as that of the sperm has the haploid number of chromosomes—14, thus giving the total of 70. These larvæ produced by irradiation live in the laboratory as long as the controls. Ultra-violet radiations also change the original polarity of Nereis eggs and embryos. Eggs exposed before insemination show the site at which the egg is "hit" by the rays, since there is a blister at this place in the cortex. The first cleavage plane always passes through this area. As the eggs are not oriented for exposure to the rays, any region may be affected, the animal pole, vegetal, or any point in the infinite number between. Hence there is an alteration of polarity. The larval worms show a definitely localized area of injury which can be traced back to this original injury by the rays. The method of irradiation has also been used in various studies of artificial parthenogenesis and cross-activation that have sought to determine the rôle of maternal and paternal pronuclei and of the egg cytoplasm (*cf.* G. Hertwig, '13). While the results have not been revolutionary, it has been shown that irradiation furnishes a means of destroying parts of eggs, particularly the nucleus, in a way that can hardly be approached by mechanical operations. Moreover, it can be used effectively upon eggs *en masse* and without the toilsome procedure of operating with varying success upon each individual cell. In general, these results that have been obtained by irradiation as a technique of research within the field of embryology promise a method by which one may hope to destroy or derange parts of cells and embryos, without injury to the whole, in a manner that makes the finest mechanical operations crude by comparison. With such a technique, important advances may be expected in a renewed attack upon ontogenetic problems.

Turning to another field, Mavor, in studies conducted since 1920, has confirmed the selective action of X-rays upon undifferentiated tissues and upon germ cells in *Drosophila*. The resistance to lethal doses of the rays remains the same during the larval period; but increases markedly during pupation, when the adult parts are being differentiated, until it reaches a new level of stability in the imago. The most susceptible period in the germ-cell cycle is the growth period of primary oöcytes and spermatocytes in *Drosophila* as in other forms. Upon the basis of this underlying phenomenon of selective action by the rays, Mavor has produced non-disjunction in which

the eggs either lacked the sex chromosome or possessed two sex chromosomes. Eggs having two sex chromosomes, when fertilized by a Y-bearing sperm, produced exceptional females which in turn produced exceptional daughters and thus propagated the condition brought about by the irradiation. There is, therefore, in this effect of X-rays on germ cells a very clear case of an external agent which modifies the mechanism of inheritance in such a way that a permanent effect is produced. In like manner Mavor has effected by use of X-radiations a reduction of the crossover value in the left half of the first or sex chromosome by X-rays, and an increase of the crossover value in the middle region of the second chromosome. He has also produced gynandromorphs from X-rayed mothers, presumably by elimination of the sex choromosome after fertilization. It is further interesting, as shown by X-raying the anterior and posterior halves of pupæ, that these effects upon the germ cells are not produced when a part of the fly not containing the germ cells is treated. That is, the effects probably occur only when the germ cells are subjected to irradiation and not through any influence transferred from irradiated body cells to the germ cells. It thus appears from the work of Mavor that X-radiations can modify the mechanism of inheritance, through chromosomal changes, in such a manner that permanent effects are produced and transmitted through successive generations without lethal abnormalities. The germ-plasm is changed, but not by the method of the Lamarckians.

The recent work of Muller upon *Drosophila* is widely known. Muller considers the changes he has produced by X-rays truly mutational and not to be confused with the well-known effects of the rays upon the distribution of the chromatin, like non-disjunction and non-inherited crossover modifications. Briefly, he finds that exposure of the sperm to relatively heavy doses of X-rays induces the occurrence of true "gene mutations" in a high proportion of the germ cells. The nature of the crosses was such as to be much more favorable for the detection of mutations in the X-chromosomes than in the other chromosomes, so that most of the mutant genes dealt with were sex-linked; there was, however, ample proof that mutations were occurring similarly throughout the chromatin. When the heaviest treatment was given to the sperm, about a seventh of the offspring that hatched and bred contained individually detectable mutations in their treated X-chromosome. Estimates of the mutations presumably produced in all the chromosomes indicate that the heavier irradiation had caused a rise of about fifteen thousand per cent. in the mutation rate over that in the untreated germ cells. Lighter irradiation produced the gene mutations in lesser numbers. "The visible mutations caused by raying were found to be similar, in their general characteristics, to those previously detected in non-rayed material in the extensive observations on visible mutations in *Drosophila* carried out by Bridges and others." Mutations already familiar, like "white eye," "miniature wing," and "forked bristles," were obtained, and also mutations of a sort not exactly like any seen previously. Muller, therefore, concludes that: "many of the changes produced by X-rays are of just the same kind as the 'gene mutations' which are obtained, with so much greater rarity, without such treatment, and which we believe furnish the building blocks for evolution." He also finds many inherited disturbances in the crossover frequency. In confirmation of these results, Hanson, who has been studying the effects of irradiation upon the sex-ratio of *Drosophila*, has obtained what he considers gene mutations as well as mutations that are seemingly due to chromosomal changes.

It thus appears that two types of genetic modification may be produced in *Drosophila* by the X-radiations—an aberrant distribution of chromosomes and hence new combinations of characters, and gene mutations. In confirmation of these findings in an animal, Stadler reports the production of both types of mutation in plants. In corn, irregular distribution of chromosomes occurs with a certain low frequency in the early cell divisions in endosperm development. This results in mosaic seeds, in which a portion of the endosperm lacks one or more chromosomes. The frequency of occurrence of this phenomenon has been increased about thirty-fold by X-ray treatment at the time of fertilization. Again, in young seedlings of barley Stadler has produced gene mutations by similar irradiation. In this instance the possibility that the gene mutations may in reality be the result of an irregular segregation has been eliminated. These mutations reported in barley are induced in somatic cells, from each of which a self-fertilizing inflorescence is later derived. Each mutant, therefore, segregates in the progeny of a single head, and its absence in the progeny of other heads of the same plant proves that the change occurred in the ontogeny of the plants irradiated. Several viable and morphologically distinct recessive types of such gene mutations have occurred in the progeny of the plants thus subjected to irradiation. To these studies by Mavor, Muller, and Stadler may be added the recent work of Gager and Blakeslee upon *Datura*, which shows irregularities of chromosomal behavior as a result of X-irradiation and which suggests gene mutations and other intra-chromosomal changes. The results reported by Goodspeed and Olson upon tobacco plants seem to be

in this category, since they do not clearly indicate gene mutations.

From the theoretical standpoint, the chief interest of such results within the field of genetics lies in their bearing upon the problem of the composition and behavior of chromosomes and genes, and thus upon the mechanism of heredity, variation, and evolution. From the practical standpoint, any technique that will induce abundant mutations presents opportunities for the production of improved breeds of domesticated animals and plants beyond anything dreamed of by the slow method of selecting what nature offers. To secure mutations that he desired, Burbank raised plants by the millions, discarding the ninety-and-nines. The advantage of more frequent mutations is obvious. On the medical side, these results, as Muller explains, point to dangers in the practice of temporary sterilization by irradiation. Return of fertility after irradiation does not mean that the germ cells are again normal, since mutations may have been induced that will appear in descendants with disastrous consequences.

Fully developed as well as latent genetic characters may be changed by irradiation. As part of a general program dealing with the biological effects of X-rays, Hance and Murphy have found that following certain exposures the colored hair of agouti mice drops out and after four or five weeks is replaced by white hair. Thus, in an adult animal, a character that is known to be inherited according to the Mendelian law can be changed by the X-radiations. The change seems permanent, as it has persisted for more than twelve months without modification. Speculating upon the causes of such an effect, Hance suspects destruction at its source of the enzyme tryosinase, the color activator, and hence failure of the oxidation of the color base, tryosin. At first what seem to be colorless tryosin granules are recognizable in the hairs, but later the hairs are without such granules and thus resemble the hairs of a normal albino. Nevertheless, "a permanent change has been produced in a mature genetic character by means of X-rays. It is believed that this change is the result of the inhibition or actual killing of the part of the cell concerned with the manufacture of the enzyme needed in the production of color. Since the new color, or rather lack of color, is permanent, it follows that the alteration is passed on to the cells that replace the ones that first encountered the X-rays."

A most interesting attack upon the entire problem of irradiation is being undertaken at the University of Cincinnati, under the leadership of Dean Herman Schneider and Professor George Sperti. The organization of this research is such that individuals in all the related fields, such as physics, chemistry, mathematics, bacteriology, zoology, and physiology, work in intimate association and with mutual support in a laboratory organized for basic investigations. By means of more accurate filters than have been previously used, these investigators have determined critical wave lengths at which chemical dissociation is produced in certain inorganic compounds, and in certain enzymes. They have also determined a wave length at which death occurs in many species of bacteria, and in a variety of the lower animals. Working with ultra-violet radiations, they find, for example, that all bacteria, thus far subject to investigation, are killed when a certain wave length (about 2900 A°) is reached. These particular results have been turned to practical advantage by patenting methods of sterilization for commercial products, the royalties from which are to be used in support of subsequent investigations. A specific example is that of an enzyme that was placed on the market for bread-making, but proved unusable because of bacterial contamination. To kill the bacteria by heat would have destroyed the enzyme, to kill them by antiseptics was not possible in a food product. When the problem was presented to the group at Cincinnati, the solution that suggested itself was to use a wave length that would kill the bacteria, but not destroy the enzyme, since it had been found that the lethal wave length differed in the two instances. The attempt was successful and I understand that the enzyme, minus the troublesome bacteria, is now in use.

To consider more general aspects of the problems open to attack by this new technique, one may distinguish between the obvious morphological and physiological effects produced by irradiation, in destruction of cells and modification of functions, and *how these effects are produced,* that is, the nature of the action of radiations upon protoplasm. The histological and cytological effects can usually be determined with no great difficulty. If one merely attempts destruction of certain parts in order to determine their rôle in development, as with the formative cells of planarians, one may leave the question of how these effects are brought about to investigators whose competence lies within the physico-chemical field. But the problem of how the changes are produced commands attention, because of its intrinsic interest and because it is likely to give clues to physiological processes that have eluded our understanding. This indeed may be the more important item in the end. Most investigators have used the methods of the morphologist. It is clear, however, that disturbances which effect changes that can be directly observed in cells are likely to be of a rather gross nature and that the more delicate functions of cells can not be adequately determined by such methods. Perhaps the studies

upon the effects of irradiation in *Drosophila*, spectacular though they are from the standpoint of heredity, will prove more important as a means of detecting physiological changes, too subtle for other modes of demonstration, than as a means of changing genetic constitution. Such studies provide a means of analyzing the effects of X-rays on cells. They show how X-rays may produce a permanent change in a cell without altering its vitality. A method of experimentation has been developed indicating lines of further investigation which may help toward a clear understanding of the exact physical and chemical changes produced by X-rays in living protoplasm, and so of hidden physiological processes. This physiological aspect of the problem can not be elaborated within the limits of the present discussion, but it may be cited as an important field of investigation that is opened by the method of irradiation.

From the morphological standpoint, intensive study should now be directed to the changes produced within the cell. It was formerly believed that the cell was most sensitive during the period of mitosis. It still seems that chromatin is particularly susceptible to radiations, but it now appears that cells are most susceptible during the period just preceding mitosis. Thus, Mohr ('19) has shown, in his classic experiments with radium upon the locust, *Decticus*, that the primary spermatocytes and oöcytes are most sensitive during the growth period, although the cells may be easily affected during the maturation divisions. Working with cells from chick embryos under soft X-rays in tissue-cultures, Strangeways and Oakley ('23) have shown that the cell phases are affected in the following order: first the prophase; next, the later phase of mitosis; and last the inter-division phases of the cell cycle, although many of these "fully formed cells" remain normal in appearance even after prolonged exposure. These investigators have also demonstrated a latent period of about 15 to 20 minutes before the effects upon the cells can be recognized. It appears, however, that the changes produced by the radiations are not specific, since they resemble those in cells growing in unfavorable or in modified media. With lesser exposures, mitosis could be checked, but was resumed after a time if the cultures were returned to the incubator. Although the nucleus and particularly the chromosomes seem most sensitive to irradiation, the cytoplasm is also affected as Packard ('16) and others have shown. It even seems that one can distinguish between a primary effect upon the nucleus, as seen in the mitosis immediately following, and a secondary effect that occurs first in the cytoplasm although it is more apparent in the nuclear changes that it eventually produces (G. Hertwig, '20 and A. Politzer, '25). Between these two effects there may be a period of seemingly normal nuclear division (Stein, '26).

The study of physical and chemical changes within cells is subject to great limitations as compared with the study of such changes in non-living bodies. Methods of chemical analysis and synthesis have only limited applications, since they kill cells at the outset wherever they are applied effectively. Evidence from staining is subject to similar limitations. Microdissection supplements these methods, but has its own disadvantages. By such means, we "know in part and we prophesy in part" when we attempt "to prove all things" concerning cell activities. Results like those obtained by the group at Cincinnati, in destroying specific chemical compounds by specific wave lengths, suggest that it may be possible to destroy visible substances within nucleus or cytoplasm without lethal injury to the cell and thus identify their chemical nature. Such a method may lead to results undreamed of in our present philosophy of cell physiology. Consider what might be done with the problems related to the cytoplasm by such a technique. Results no less remarkable seem to have been accomplished in the nucleus without lethal injury to the cell.

We are thus confronted by the fundamental physiological problem, *the nature of the effects of radiations upon the cell.* Of this we know relatively little, although one can by irradiation change the nature of cells without lethal injury, as the geneticists have done; or completely destroy one type of cell without apparent injury to other types in the same organism, as in the familiar cancer therapy and as I have done in experiments with planarians. The only effect of the absorption of X-rays by an atom that physicists recognize is the expulsion of a high-speed electron. This must be the starting point in any purely physicochemical theory of the action of X-rays upon protoplasm. The problem is one for the biophysicist. If he can solve it, we may hope for notable advances in our knowledge of cellular physiology.

Problems that demand immediate investigation, if biologists would make full use of the X-rays and other radiations as an instrument of research, are: the exact measurement of exposures, the cause of the latent period, the "differential" action of diverse wave-lengths, and whether light exposures actually have the stimulating effects that have been claimed. Fields of biological investigation that seem most vulnerable to an immediate attack by this technique of irradiation are: morphogenesis, heredity, and the physiological effects of radiations.

Belief that the method of irradiation presents alluring possibilities as a tool of biological investigation therefore seems justified by results already accomplished. It is possible by use of radiations to destroy

certain types of cells, as though by a surgical operation of surpassing delicacy. We can also reach within the cell and effect changes, particularly in the nucleus. It seems that we can even change the genes and thus inheritance. Most important of all, irradiation promises clues to basic physiological processes. In medicine it has found many applications. It may assume equal importance in the breeding of domesticated plants and animals. In the general field of biological science it offers a new technique before which old problems may fall.

WINTERTON C. CURTIS

UNIVERSITY OF MISSOURI

SPACES OF STATISTICS AND THEIR METRIZATION[1]

WE may generalize the ordinary statistical graph by considering an n-dimensional space in which each coordinate represents a statistical variate. How much arbitrariness is there in the choice of a particular coordinate system? In many familiar cases almost any change of coordinates is meaningless; geometry can then hope to throw but little light on the problem, compared to that which it supplies for physical problems, in which such transformations as those of the Euclidean group are held not to change the nature of the case. But certain situations arise in which real invariant properties exist for rather extended groups of transformations.

One of these cases is in economics. Let $p_1, p_2, \ldots, p_n$ be the prices of n commodities; and with these prices ruling, let $q_1, q_2, \ldots, q_n$ be the respective quantities that can be sold. Now the same market situation can be expressed otherwise by giving the commodities different definitions; *e.g.,* a certain quantity of iron and wood will make a certain number of Fords and a certain number of garages; if we know the equations of transformation we have the same information given by either pair of quantities. Wheat of different grades can be, and is, mixed in different ways to meet the grading systems in different countries. We can readily prove that under these transformations in the manifold of prices, quantity is a covariant vector. Dually, in the manifold of quantities price is a covariant vector.

Another example is in biology. If an individual be regarded as fully specified by the dimensions of n organs he is, by definition, a point in a space of n dimensions. A species is a cluster of points, and may be typified by its center of gravity. Coordinates may be transformed by changing the methods of measurement; thus we may give the height of a man's shoulder and the length of his arm, or we may give the height of his hanging hand and the length of his arm.

But in all this no invariant distance element has appeared. We are impelled to look about for some quadratic form, preferably a quadratic differential form, of statistical significance.

Now a quadratic form of overshadowing importance is found in the exponent of the normal law of probability in n variables. The various reasons for adopting this law are strongest when the deviations of which the quadratic form is a function are small, and so it is natural to take it as a quadratic differential form.

The idea of random migration has received much mathematical consideration by Karl Pearson, Lord Rayleigh and others. It may be applied to particles in a biological n-space to discuss evolution. A son differs from his father in n ways; if these deviations are all independent and have equal dispersions, the probability of a set of deviations $\delta x_1, \ldots, \delta x_n$ is proportional to e^{-T}, where T is a constant multiple of $\delta x_1^2 + \delta x_2^2 + \ldots + \delta x_n^2$, and so may be said to define the *distance* from father to son. If the deviations are not independent, product terms $\delta x_i\ \delta x_j$ appear in T. If finally the dispersions and degrees of interdependence of the δx's depend on the x's we have the quadratic differential form with variable coefficients, and therefore a Riemannian geometry. That the dispersions do in fact vary with the size is evident by considering the difference in centimeters in the length of a pair of twin elephants, and then comparing this with the variability in length in a litter of mice. It may safely be assumed that the intercorrelations, for a given species, may also vary with size and shape.

In this way we obtain a metrical space, in general curved, as a matrix for possible organisms. A species, represented by a swarm of particles, diffuses gradually by an accumulation of small changes in a manner analogous to the conduction of heat in this curved space. It would eventually become so diversified as to supply the naturalist with every conceivable kind of specimen were it not for the effect of selection. This may be pictured as a system of heat "sinks," of refrigerated localities, spread here and there to trap and annihilate unwary individuals. On the whole the losses due to the sinks are of course made good by natural increase.

The center of gravity of a swarm of individuals may be taken to represent the species. Suppose that we have a collection of fossils which shows us the location of this point at each of two times a million years apart; it is desired to know its most probable positions at intermediate times. If we have no

[1] Presented to the American Mathematical Society, September 9, 1927.

"sinks," no selective action, then the most likely path is a geodesic. If we do have "sinks" they act as propulsive forces and we encounter the following generalization of the theory of differential equations. At each point, instead of having a definite direction of motion assigned, as by differential equations, we have a pencil of directions (or an (n–1)-parameter family of directions) with a function, which will be a normal error function, giving the probability that the direction of motion will lie between any assigned limits. This enables us to assign to the curves joining two points a distribution of a species of probability. For fixed end points the selection of the most probable curve is a problem in the calculus of variations. If g_{ij} is the fundamental tensor and φ_i a vector giving the most probable direction we shall in fact minimize

$$\int_{t_1}^{t_2} \sum_{i,j=1}^{n} g_{ij}(\dot{x}_i - \varphi_i)\,(\dot{x}_j - \varphi_j)\,dt,$$

where $\dot{x}_i = dx_i/dt$.

The minimizing equations for the integral may be interpreted as the differential equations of a dynamical system. Indeed we may consider the most probable path as the trajectory of a particle shooting through the curved space under a field of force. However, the form of the integral shows that the force will in general depend upon the direction of motion, as with an electrical charge moving in a magnetic field.

The derivation of the criterion that the integral shall be minimized is a simple generalization of a derivation in the article on "Differential Equations subject to Error, and Population Estimates,"[2] in which I use the same considerations in their simplest form to obtain estimates of intercensal populations. That was in one dimension, but it may readily be generalized by considering a system of variables having correlated changes, such as the population of a city, the number of children in its schools, the number of telephones and so on. The leading difficulty in applications of this kind is to arrive at the tensor g_{ij}.

There is nothing to prevent empirical determination from measurements of parents and offspring of the fundamental biological tensor giving the distance element which we have defined. In fact all the measurements which have been made in the study of heredity may be regarded as steps in this enterprise. As a sufficient accumulation of data makes the hypothesis of flatness untenable we shall be driven to look for some other kind of space, as simple as is possible without contradicting the data. A space which in some sense or other has constant curvature will be wanted as a second approximation, and mathematicians will be asked to supply equations of suitable type, with parameters for biological workers to determine empirically and check by tests of goodness of fit.

This problem which biology is approaching has already been faced by physics. The hypothesis of Euclidean space-time as a matrix of physical events served adequately for several centuries; but more refined measurements have required its modification. Mathematical physics has been grappling with the problem of supplying as simple a statement as possible of the properties of the world-order without contradicting known facts. Such a statement is indeed what we call an explanation. It is altogether likely that the considerations of simplicity which led Einstein to his cosmological equations may some day cause the same equations to appear as the foundation of biology.

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[2] *Journal of the American Statistical Association*, September, 1927, pp. 283–314.

PAUL HEINRICH VON GROTH

IT is with deep regret that we record the death of Professor Paul Heinrich von Groth in Munich, Germany, on December 2, 1927. With the passing of Professor Groth the Mineralogical Society of America has lost one of its most distinguished honorary life fellows, the science of mineralogy one of its greatest leaders and the world of science a courageous pioneer, an ardent investigator, an energetic and efficient author and editor and an inspiring teacher.

Paul Heinrich von Groth was born on June 23, 1843, at Magdeburg, Germany. His father was a portrait painter. The training for his life's work Professor Groth obtained at the school of mines in Freiberg, at the college of engineering in Dresden and at the University of Berlin, at which institutions he spent the years 1862 to 1870. The degree of doctor of philosophy was conferred upon him by the University of Berlin in 1868.

From 1870 to 1872 Professor Groth was a member of the teaching staffs of the Technische Hochschule in Charlottenburg and of the University of Berlin. When the University of Strassburg was being reorganized, shortly after the close of the Franco-Prussian war, Groth was called to the chair of mineralogy, for he had already acquired a splendid reputation as an investigator of great promise, especially in the field of chemical crystallography, to the development of which he subsequently contributed so extensively.

Groth held the professorship at Strassburg from

1872 to 1883. During this period he not only supervised the construction of a new laboratory, which set a very high standard for that time, and completely reorganized the mineral collections, but he also carried on extensive researches and published a long list of papers. Moreover, it was while at Strassburg that Groth began his notable career as an author and editor, for during that period he wrote two text-books and a guide to the mineral collections and founded the *Zeitschrift für Kristallographie und Mineralogie*.

Thus, in 1874, the first edition of his "Tabellarische Übersicht der Mineralien" was published, which later appeared in four German editions and in 1904 was translated into French. Two years later, in 1876, his "Physikalische Kristallographie und Einleitung in die Kenntnis der wichtigen Substanzen" appeared. This soon became the standard text in the field of physical crystallography, and later passed through four German editions. In 1910 this important text-book was made more directly available to English-reading students, when portions of it were translated into English by Jackson. The third book to be written by Groth while at Strassburg was the excellent guide to the mineral collections of the university, published in 1878.

As already indicated, the *Zeitschrift für Kristallographie und Mineralogie* was founded by Groth. It was first issued in 1877. As sole editor Groth published 52 volumes of the *Zeitschrift* and three more as joint editor with Professor E. Kaiser, making a total of 55 volumes during the years 1877 to 1920. As is well known, since 1921 the *Zeitschrift* has been under the editorship of Professor P. Niggli, of the University of Zürich. Upon the occasion of Groth's eightieth birthday, in 1923, the 58th volume was issued as a Groth Festschrift, and contained 32 papers by his friends and former students.

In 1883 Professor Groth was called to the University of Munich as the successor to Professor Franz von Kobell. His tremendous energy was at once transferred to that institution, and he soon reorganized the instruction in mineralogy and installed in new quarters the extensive royal Bavarian mineral collections, of which he was made custodian. Under Groth's leadership the Mineralogisches Institut of the University of Munich became one of the chief centers for crystallographic and mineralogical study, advanced students being attracted from all over the world, particularly from the United States.

During his professorship at Munich Professor Groth stimulated and supervised many investigations dealing with various phases of crystallography and mineralogy. He also continued to write text and reference books and 13 additional volumes were placed to his credit, of which only the following will be mentioned: "Grundriss der Edelstein-Kunde" (1887), the monumental work on "Chemische Kristallographie" in six volumes (1904 to 1919), "Elemente der physikalischen und chemischen Kristallographie" (1921), and "Die Entwickelungsgeschichte der mineralogischen Wissenschaften" (1926). The last book was published after his retirement from active teaching and when he had all but lost his eyesight.

Professor Groth's contributions to the mineralogical sciences were widely and most favorably recognized for he was elected to honorary membership in many learned societies. Since he had had many students from the United States and Canada it, indeed, was fitting that he should have been elected an honorary life fellow of the Mineralogical Society of America in 1926. Prominent universities also gladly testified to Professor Groth's preeminent position among the world's leading scientists of his period, the Universities of Cambridge and Geneva having conferred upon him the honorary degree of doctor of science and the University of Prague that of doctor of philosophy.

Professor Groth's activities were so varied and many of his contributions so fundamental and far-reaching that they exercised a profound influence not only upon the development of mineralogy but also upon certain phases of chemistry and physics. Accordingly many of his views on morphotrophy and isomorphism and on chemical crystallography in general have become firmly embodied in chemical literature. Furthermore, the remarkable advances in our knowledge of crystal structure as the result of the development of X-ray analysis, dating from 1912, are in large measure due to Groth's long and enthusiastic advocacy of the point system theory of crystal structure.

Until the very last Professor Groth was keenly interested in American mineralogy. In 1893 he came to the United States and served as a member of the jury of awards for the division of Mines and Minerals of the World's Exposition held in Chicago that year. While in this country he visited some of our leading universities, museums and mining and mineral localities.

In March, 1926, I was privileged to visit Professor Groth twice in his home in Munich. Although he was then in his eighty-third year and nearly blind, he displayed the same enthusiasm for his beloved science and still retained the alertness of mind that had attracted so many students to him and inspired them to achievement. At that time he eagerly inquired about his friends and former students in this country and Canada.

During the 60 years of Groth's activity, crystal-

lography has passed by various stages of development from the list of the more or less descriptive sciences to that of the exact sciences permitting of precise measurements. To this advance Professor Groth and his many students contributed in no small measure.

EDWARD H. KRAUS

UNIVERSITY OF MICHIGAN

SCIENTIFIC EVENTS

THE ELLA SACHS PLOTZ FOUNDATION FOR THE ADVANCEMENT OF SCIENTIFIC INVESTIGATION

DURING the fourth year of the Ella Sachs Plotz Foundation for the Advancement of Scientific Investigation the total number of grants made was twenty-four. Seventeen of the new grants were made to scientists in countries outside of the United States. In the four years of its existence the foundation has made fifty-five grants and investigators have been aided in the United States, Great Britain, France, Germany, Austria, Hungary, Switzerland, Italy, Sweden, Esthonia and Czechoslovakia.

The list of investigators and of the researches which have been aided in the current year is as follows:

Dr. William deB. MacNider, University of North Carolina Medical School, $500 a year for two years for further studies on experimental nephritis.

Dr. W. W. Swanson, University of Minnesota, $500 for an investigation of the osmotic pressure of the plasma proteins in nephritis.

Professor Dr. W. Weichardt, Erlangen, $250 for an investigation on a scientific basis for nonspecific therapy.

Professor Dr. W. Schlayer, Berlin, $250 for a study of the exchange of various substances, including indican and uric acid, from the tissues to the blood.

Dr. Leo Hess, Vienna, $200 for a study of the biology of jaundice.

Dr. Hermann Sternberg, Vienna, $250 for physiological, pharmacological, histological and pathological investigations of the respiratory tract, particularly as concerns hay-fever, asthma and vasomotor rhinitis.

Dr. David Scherf, Vienna, $250 for animal experiments on arrhythmia of the heart.

Dr. Alfred Neumann, Vienna, $280 for a study of the chemical and biological characteristics of the granules of leucocytes.

Dr. Leon Asher, Berne, $250 for a study of the mechanism of the so-called autonomic poisons or drugs.

Professor O. Loewi, Graz, $500 for researches on the mechanism of insulin effect and diabetes.

Professor Dr. Ernst Loewenstein, Vienna, $1,000 for a study of the chemotherapy of infectious diseases, especially of tuberculosis.

Dr. Waldemar Gohs, Vienna, $279 for researches on bacteriophage.

Professor Maurizio Ascoli, Catania, $1,000 for research on the prevention of Malta fever.

Dr. R. Wartenberg, Freiburg, $200 for continuation of encephalographic and myelographic studies.

Dr. Andrea Andreen Svedberg, Stockholm, $550 for research on intermediary metabolism of carbohydrates with special reference to diabetes in dogs and men.

Dr. Robert Chambers, Cornell University Medical School, $750 for a study of the reaction of protoplasm under various physiological, pathological and pharmacological conditions.

Dr. Charles Hruska, Ivanovice, $500 for a study of immunity in anthrax.

Professor Leon Blum, Strasbourg, $1,000 for researches on nephritis and study of the therapeutics resulting from them.

Dr. Erwin Becher, Munich, $300 for investigations in uremia.

Dr. Henry G. Barbour and Dr. R. Glenn Spurling, University of Louisville School of Medicine, $750 for investigations on the prevention of fluid loss from the circulation.

Dr. M. S. Dooley, University of Syracuse, $700 for studies on the direct and indirect effects of drugs, including anesthetics, upon the medullary centers.

Dr. Ernst Weichmann, Cologne, $250 for a study of permeability of cells.

Thorndike Memorial Laboratory, Boston City Hospital, $500 a year in recognition of Dr. Peabody's services.

Dr. James E. Dawson, Edinburgh, $250 a year for two years (made in 1926) for investigation on the pathology of the breast.

THE JOURNAL OF THE SWEDISH FORESTRY SOCIETY

WITH the volume of 1927 *The Journal of the Swedish Forestry Society* (Svenska Skogsvardsföreningens Tidskrift) completes its 25th year. During the last quarter century it has taken a leading place among the technical forestry journals of the world, and the growing interest during the past decade for Swedish forestry has been due no little to the excellence of this publication in presenting the results of research to the world. Recognizing the increasing international interest in forestry, and forest research in particular, the editors announce the following new policy, beginning with the 1927 volume:

1. The journal will be devoted exclusively to reports of scientific forest investigations and papers on forest policy and forest economics. Book reviews will be included, but all notices, etc., of local interest only will be published in the popular bimonthly organ "Skogen" ("The Forest").

2. All articles will be accompanied by full résumés in French, German or English.

3. Papers of more general international interest will be published *in extenso* in one of these languages.

In embarking on this policy, the editors are following the custom of other scientific journals of international appeal. In view of the changes which now

enable the journal to address itself to a wider reading public, it is earnestly hoped that American foresters, ecologists, pathologists, entomologists and research workers in other branches of biological science will give the publication their hearty support.

The editor-in-chief is Professor Henrik Hesselman, in charge of the natural science division of the Swedish Institute of Experimental Forestry (Statens Skogsförsöksanstalt), and was chairman of the section on forest soils at the International Congress of Soil Sciences at Washington in 1927. The assistant editor is Erik Lundh, secretary of the Swedish Forestry Society and docent at the Forest School.

The journal will be published in four large parts each year, two before and two after the summer. Owing to the fact that the reports of the experiment station (Meddelanden fran Statens Skogsförsöksanstalt) are published by the society, arrangement can be made to have them accompany the journal as supplements. Both publications are printed in large, readable type on heavy glazed paper, and are profusely illustrated with many clear illustrations, graphs, tables, etc. Colored plates are frequently included. The journal thus offers a very attractive medium for publication, and it is to be hoped that American investigators may be interested in submitting manuscripts. The undersigned has consented to act as American representative, and will be glad to answer inquiries regarding subscriptions and advertising, and forward material submitted for publication. A limited supply of sample copies of the last volumes of the "Tidskrift" and "Meddelanden" are available and will be sent on request to organizations and individuals interested.

HENRY I. BALDWIN

BERLIN, NEW HAMPSHIRE

STATEMENT REGARDING THE DISMISSAL OF THE HEALTH COMMISSIONER OF CHICAGO

FOLLOWING the dismissal of Dr. Herman N. Bundesen, former health commissioner of Chicago, and his replacement by Mayor Thompson's personal physician, a surgeon with no public health training, a public statement has been issued by many prominent men in public health work in the United States, protesting against the influence of politics affecting the public health and welfare of the people at large. Not only has Dr. Bundesen been eliminated from Chicago's health department, but also his principal assistants, J. C. Geiger, M.D., deputy health commissioner; Arthur E. Gorman, chief sanitary engineer, and I. S. Falk, Ph.D., director of surveys.

The statement reads:

The undersigned workers in the field of American public health desire to express an emphatic protest against the action of the Mayor of the City of Chicago in replacing Dr. Herman N. Bundesen, the health officer of that city, by a physician who, whatever his personal standing, is without apparent qualifications or experience to fit himself for the discharge of the serious duties of the office in question.

Permanence of tenure for competent health officials is an absolutely essential factor in the protection of the public against preventable disease; and the case in question seems particularly flagrant in view of the extraordinary record of Dr. Bundesen, whose brilliant services have aroused nation-wide admiration. Sacrifice of the lives of citizens of Chicago to political exploitation and personal whims is more than a local matter, since unsanitary conditions in one community may react upon an entire continent.

The action of the mayor of Chicago strikes a blow at the most fundamental principles of good government. It should meet with prompt and vigorous rebuke from all people of Chicago who care for the reputation of their city and it should stimulate citizens everywhere to see that city charters are amended so as to make such interference with good health administration impossible in their own communities.

The statement is signed by twenty-three men eminent in the field of public health including: Dr. A. C. Abbott, director, School of Hygiene and Public Health, University of Pennsylvania; Dr. Charles V. Chapin, superintendent of health, Providence; Dr. Haven Emerson, professor of public health administration, Columbia University; Dr. Livingston Farrand, president, Cornell University; Dr. Allen W. Freeman, professor of public health administration, the Johns Hopkins University; Dr. Louis I. Harris, commissioner of health, New York City; Dr. William H. Howell, director, School of Hygiene and Public Health, the Johns Hopkins University; Dr. William H. Park, director, bureau of laboratories, Department of Health, New York City; Dr. Ray Lyman Wilbur, president, Leland Stanford University, and Dr. C.-E. A. Winslow, professor of public health, Yale University.

REPORT OF THE DELEGATE OF THE BOTANICAL SOCIETY OF AMERICA TO THE THIRD PAN-PACIFIC CONGRESS

THE following is the report of the delegate of the Botanical Society of America to the third Pan-Pacific Congress:

TO THE SECRETARY,
BOTANICAL SOCIETY OF AMERICA.

It is desired that what follows may be considered to be a brief and informal report of the delegate of the

Botanical Society of America to the Third Pan-Pacific Science Congress held at Tokyo, Japan, whose scientific formal program extended from October 30 to November 11, 1926, but whose more extended excursions began October 18 and continued until November 19. During the whole of this considerable period, the delegates participating (together with their accompanying families) were regarded as the guests of the local committees and all living and traveling expenses provided for out of funds at their disposal. Your delegate joins the other foreign delegates in feeling that no form of words is adequate for the expression of their appreciation of the wonderful hospitality of the Japanese Government and its official representatives and of the marvelous executive ability and extreme courtesy of its citizens of both high and low degree. The management of the complicated detail of the scientific, social and travel program is beyond ordinary expression of sincere and genuine praise.

The particular general achievement of the congress was the effecting of a permanent organization to perpetuate its work and continue its ideals. The "*Pacific Science Association*" came into being at the closing general session, the units being the National Research Councils, or other outstanding scientific body, of each Pacific unit of territory. A constitution and by-laws were adopted and Java was selected for the next meeting with 1929 as the year for reassembling.

The principal measures of botanical interest instituted or sanctioned by the proceedings of the congress are:

(1) The representation of biology on the Committee for Oceanographic Research;
(2) The inclusion of endemism and migration with reference to the insular floras (and faunas) of the Pacific Ocean;
(3) Geological and paleontological evidence as to the shores of the Pacific in divisions of Tertiary time (this having relation to existence or non-existence of land bridges);
(4) The botanical point of view as preeminent in the investigation of the coral reefs of the Pacific Ocean;
(5) The resolution calling for the setting aside of localities of particular botanical interest, and
(6) The resolution urging the Chilean Government to take measures looking towards the protection of the peculiar floral features of the Juan Fernandez Islands.

Your delegate attended a luncheon given by the Botanical Society of Tokyo to visiting botanists, delivered three papers, *viz.*—"Endemism and Migration with Particular Reference to the Floras of the Pacific Islands," "Coral Reef Problems in the Pacific and Indian Oceans" and "A Botanical Point of View of Coral Reef Theories, with Especial Relation to the Coral Reefs of the Pacific Ocean." He also proposed a resolution to institute a committee to be composed of biologists, oceanographers and geologists to outline the problems connected with the origin and growth of the coral reefs of the Pacific Ocean and to suggest methods of investigation for their solution. This resolution was adopted by the congress.

Respectfully submitted,

(Signed) W. A. SETCHELL,
Delegate

The following resolution was adopted by the society at the recent Nashville meeting.

The Botanical Society of America wishes to express, through Professor Sakurai, its deep appreciation of the unusually successful conduct of the Third Pan-Pacific Science Congress convened at Tokyo in October and November, 1926; and to thank the Imperial Japanese Government for making possible a meeting of such significance for scientific and international cooperation. It wishes also particularly to thank the Botanical Society of Tokyo, the Botanical Institutes of the Imperial University of Tokyo, and the other scientific organizations of Japan for the assistance generously extended to the American delegates and for their delightful hospitality throughout the extended period before and after the meetings of the congress, during which they traveled and studied in Japan.

SCIENTIFIC NOTES AND NEWS

DR. HENDRIK LORENZ, professor of mathematical physics at Leyden, died on February 25, at the age of twenty-five years.

THE Faraday medal "for notable scientific or industrial achievement in electrical engineering or for conspicuous service rendered to the advancement of electrical science" has been awarded by the Institution of Electrical Engineers, London, to J. A. Fleming, F.R.S., formerly professor of electrical engineering in the University of London.

THE council of the Geological Society has made the following awards: Wollaston Medal to Dr. D. H. Scott, lately honorary keeper of the Jodrell laboratory, Royal Botanic Gardens, Kew, in recognition of the value of his researches in fossil botany; Murchison Medal to Dr. J. J. Sederholm, director of the Geological Commission of Finland, in recognition of his researches in petrology, especially of the granites and gneisses of the pre-Cambrian complex of Fennoscandia; a Lyell medal to Professor S. H. Reynolds, C. Wills, professor of geology in the University of Bristol, in recognition of the value of his researches in the stratigraphy of the Paleozoic rocks, and in vertebrate paleontology; a second Lyell medal to Dr. W. D. Lang, keeper of the department of geology in the British Museum, for his researches in stratigraphy and paleontology, especially with reference to the Bryozoa; the Wollaston donation fund to Mr. James Wright, for his researches on the Crinoidea of the

Carboniferous Limestone of Scotland; the Murchison geological fund to Dr. George Slater, in recognition of the value of his researches in glaciology; and the Lyell geological fund to Mr. Ben Lightfoot, for his researches on the economic geology of Southern Rhodesia.

THE list of British New Year honors includes, as reported in *Nature*, the names of the following men of science and others associated with scientific work. *Baronet:* Major-General Sir Richard Havelock Charles, sergeant surgeon to the king, a past president of the Royal Society of Tropical Medicine and Hygiene. *K.C.V.O.*: Sir Frank Baines, until lately Director of Works, H. M. Office of Works. *Knights:* Professor Jahangir Cooverjee Coyajee, professor of political economy and philosophy in the Presidency College at Calcutta; F. G. Hallett, secretary of the joint examining board, Royal College of Physicians of London and Royal College of Surgeons of England; Brigadier-General H. B. Hartley, fellow and tutor of Balliol College, Oxford, and member of the chemical warfare committee; Dr. E. H. Pascoe, director of the Geological Survey of India; Principal C. Grant Robertson, vice-chancellor and principal of the University of Birmingham; Dr. T. E. Stanton, superintendent of the engineering department, National Physical Laboratory; A. E. Aspinall, secretary of the Imperial College of Tropical Agriculture, Trinidad. *C.M.G.:* Major R. G. Archibald, director of the Wellcome Research Laboratories, Khartum; Mr. O. T. Faulkner, director of agriculture, Nigeria.

THE King of Spain has conferred the grand cross of the order of civil merit on Dr. Aldo Castellani, director of tropical medicine at the Ross Institute and Hospital, London, now lecturing at Tulane University, in recognition of his investigations into tropical diseases. Dr. Castellani recently visited Madrid at the invitation of the Spanish government to lecture on the subject of malaria. The King of England has conferred the rank of honorary knight commander of the Order of St. Michael and St. George upon Dr. Castellani.

HERBERT HOOVER, secretary of commerce, has been awarded the gold medal of the American Institute of Mining and Metallurgical Engineers for "achievement in mining."

DR. ALEXANDER WETMORE, assistant secretary of the Smithsonian Institution, has been elected a corresponding member of the Zoological Society of London.

THE Woman's Medical College of Pennsylvania announced in connection with the recent celebration of the ninety-first birthday of Dr. William W. Keen that a chair of surgery will be named in his honor in the new college to be built at the Falls of the Schuylkill. The sum of $100,000 will be raised to endow the chair. Dr. Keen was for several years professor of surgery at the Woman's Medical College.

ON November 21, 1927, at the psychology laboratory of Stanford University, a dinner was held in commemoration of Dr. Frank Angell's seventieth birthday and of the thirty-fifth year since the founding of the Stanford Laboratory. Dr. Angell took this occasion to recount his Leipzig experiences with the late Professor E. B. Titchener and to describe incidents connected with the establishing of the psychology departments both at Cornell and at Stanford. A portrait of Dr. Angell was unveiled and presented to the psychology laboratory at this time. The chairman of the occasion was Dr. Catharine Cox Miles.

PROFESSOR ARTHUR H. COMPTON, recent Nobel prize winner, was guest of honor at a faculty dinner at the University of Chicago on January 12.

ALEXANDER SILVERMAN, head of the department of chemistry at the University of Pittsburgh, was tendered a dinner by the students and faculty of Bryn Mawr College on January 12, following which he delivered an illustrated lecture on "Glass: One of Man's Blessings."

THE following officers of the Botanical Society of America were elected at the Nashville meeting: *President,* A. H. R. Buller, of the University of Manitoba; *Vice-president,* I. W. Bailey, of Harvard University. Corresponding members of the society were elected as follows: Abbé Giacomo Bresadola, Professor Seiichiro Ikeno, Professor C. H. Ostenfeld, Professor Otto Rosenberg and Professor Richard von Wettstein.

AT the annual meeting of the Anthropological Society of Washington on January 17, the following officers were elected to serve for the current year of 1928: *President,* Dr. Charles L. G. Anderson; *Vice-president,* Frank H. Roberts, Jr.; *Secretary,* Dr. John M. Cooper; *Treasurer,* Henry B. Collins, Jr.

AT the annual meeting of the American Association for the Study of Allergy in Washington, D. C., Dr. Harry S. Bernton, Washington, D. C., was elected *president;* Dr. Richard A. Kern, Philadelphia, *vice-president,* and Dr. Albert H. Rowe, Oakland, Calif., *secretary-treasurer.* The next meeting of the association will be at Minneapolis on June 11.

DAVID F. JONES, Watertown, S. D., has been elected president of the American Pharmaceutical Association and will be installed at the next annual meeting.

PROFESSOR D. D. JACKSON, head of the department of chemical engineering at Columbia University, has accepted the chairmanship of the coordinating com-

mittee, which is in charge of the coming visit of English chemists and chemical engineers, members and guests of the Society of Chemical Industry.

Professor Wilder D. Bancroft, of the department of chemistry at Cornell University, has been appointed a member of the advisory committee of the cancer research fund of the University of Pennsylvania.

C. A. Brautlecht, head of the department of chemistry and chemical engineering at the University of Maine, has been elected chairman of the Northeastern division of the American Pulp and Paper Mill Superintendents Association.

William Procter, research associate of the Academy of Natural Sciences of Philadelphia, has been elected to serve on the board of managers of the Wistar Institute to fill the vacancy caused by the death of Mr. George Vaux, Jr.

The Smithsonian Institution has awarded the Walter Rathbone Bacon research fellowship for the years 1928–1930 to Dr. Paul Bartsch, curator of mollusks in the U. S. National Museum. Dr. Bartsch will make use of the award to collect material for the completion of a monograph he has long had under way on the land shells of the West Indies.

At the American Museum of Natural History Clifford H. Pope has been promoted from assistant to assistant curator of herpetology; Dr. Chester A. Reeds, curator of invertebrate paleontology, has had his title changed to curator of geology and invertebrate paleontology, and John Treadwell Nichols, assistant curator of recent fishes, has been made curator of recent fishes.

Dr. David Fairchild, senior agricultural explorer in charge of the office of foreign-plant introduction, U. S. Bureau of Plant Industry, relinquished charge of that office on January 5, and Knowles A. Ryerson assumed the direction of the office. Dr. Fairchild will continue as senior agricultural explorer and will act as adviser and consulting specialist in matters pertaining to research problems in foreign-plant introduction.

Philip G. Colin has resigned from the Rockefeller Institute for Medical Research to take a position with the Tidewater Oil Company, Bayonne, N. J.

Louis E. Dawson has resigned his position in the carbohydrate laboratory, U. S. Bureau of Chemistry and Soils, to take a position in the research department of H. O. Wilbur & Sons, manufacturers of cocoa and chocolates, Philadelphia, Pa.

Dr. N. L. Britton, director of the New York Botanical Garden, recently went to Porto Rico to continue the botanical and horticultural studies of West Indian plants.

Dr. J. W. Gidley, of the division of vertebrate paleontology in the U. S. National Museum, will leave shortly for Melbourne, Florida, where he expects to spend about two months in securing data on Pleistocene vertebrates.

Asher Hobson, permanent United States delegate to the International Institute of Agriculture at Rome, sailed for Europe on January 4. He will be located at Geneva, Switzerland, where he will gather research material in the development of a study which he has under way dealing with the institute.

Dr. F. F. Nord, of the Physiological Institute, Berlin, who worked during 1926–27 in the division of agricultural biochemistry at the University of Minnesota, addressed on his way home the Pan-Pacific Research Institute at Honolulu and delivered lectures at the Imperial University of Kyoto, the Indian Chemical Society at Calcutta and at the Universities of Patna, Benares and Allahabad.

The next series of Lane medical lectures will be given in October, 1928, by Professor F. d'Herelle, directeur du service bacteriologique du Conseil Sanitaire, Maritime et Quarantinaire at Alexandria, Egypt. The program has not been decided upon, but the lectures will probably cover filterable viruses and the bacteriophage. Dr. Walter Straub, professor of pharmacology at the University of Munich, has consented to give the Lane medical lectures in 1929. The course will probably be given in April.

Professor H. Kramers, of the University of Utrecht, will lecture at the University of Michigan during the coming summer session (June 15 to August 30). He will lecture twice a week on "Wave Mechanics" and twice a week on "Survey of Recent Work in the Quantum Theory." Courses will also be given by Drs. Uhlenbeck and Goudsmit, recently of the University of Leyden, supplementing those of Professor Kramers.

Dr. H. H. Gran, professor of botany in the University of Oslo, Oslo, Norway, will offer a course in marine diatoms at the Puget Sound Biological Station, Friday Harbor, Washington, during the session beginning on June 18.

Dr. Wade Hampton Frost, professor of epidemiology in the School of Hygiene and Public Health at the Johns Hopkins University, gave the Cutter lectures on preventive medicine at the Harvard Medical School on February 2 and 3. The subjects of the lectures were "Infection, Immunity and Disease in the

Epidemiology of Diphtheria" and "Some Conceptions of Epidemics in General."

DR. OSCAR RIDDLE, of the Carnegie Station for Experimental Evolution, Cold Spring Harbor, New York, delivered a series of six lectures during the month of January at the School of Tropical Medicine of the University of Porto Rico, San Juan, on "The Internal Secretions in Evolution and Reproduction" and "Control and Transformation of Sex in Animals."

DR. HERBERT E. IVES, of the Bell Telephone Laboratories, will address the Franklin Institute on February 15 on "Television."

DR. EDWIN HUBBLE, astronomer in the Mount Wilson Observatory, will give a lecture on February 20 in San Francisco under the auspices of the Astronomical Society of the Pacific. Dr. Hubble will speak on "The Exploration of Space."

DR. FRANCIS G. BENEDICT, director of the Nutrition Laboratory of the Carnegie Institution of Washington, gave an address at Mount Holyoke College, South Hadley, Massachusetts, on "The Heat Production of Humans and Animals and Factors Affecting it," on January 21.

DR. COLIN G. FINK, of Columbia University, gave an illustrated address on "Recent Advances in Electrochemistry" at the meeting of the American Institute of Electrical Engineers held at Waterbury, on January 24. On February 3 Dr. Fink lectured before the McGill chapter of Sigma Xi and on February 15 he will lecture to the chemical students of Yale University, on the subject "Corrosion, its Cause and Prevention."

DR. W. F. G. SWANN, director of the Bartol Research Foundation, Philadelphia, read a paper on "Theories of the Atom," before the American Philosophical Society on February 3.

A TABLET in memory of Sir William Osler was unveiled by the Hamilton Medical Society, on December 28, 1927, near his former home in Dundas, Ontario.

DR. ERNEST C. SCHROEDER died on January 24, at Bethesda, Md., where he was superintendent of the Experiment Station of the Bureau of Animal Industry, United States Department of Agriculture. During his forty years of public service Dr. Schroeder made important contributions to the knowledge of animal diseases.

DR. OWEN F. BURGER, plant pathologist of the Florida Agricultural Experiment Station, died on January 26, from injuries received in an automobile collision. Dr. Burger was forty-three years of age.

EDWARD MALLINCKRODT, president of the Mallinckrodt Chemical Works, died on February 3, aged eighty-three years. Mr. Mallinckrodt has given more than $1,000,000 to scientific education and to hospitals. The largest single item was $500,000 to Harvard for a building to house the department of chemistry.

BRADSHAW HALL SWALES, honorary assistant curator of the division of birds in the U. S. National Museum, died on January 23, in his fifty-fourth year.

CHARLES W. MEAD, honorary curator of Peruvian archeology on the scientific staff of the American Museum of Natural History, died on February 3 at the age of eighty-two years.

DR. JOHANNES FIBIGER, professor of pathological anatomy at the University of Copenhagen, who was awarded the Nobel prize last October for his work on cancer, died on January 31.

A CORRESPONDENT writes of Dr. Chase Palmer, who died in San Francisco at the age of seventy-one years on November 18, 1927, as follows: For the past few years Dr. Palmer had been engaged in research and consulting work on chemical problems with special reference to the occurrence and recovery of petroleum. His undergraduate work was begun at Princeton and continued at the Johns Hopkins, where he received the degrees of A.B. in 1879 and Ph.D. in 1882. Dr. Palmer was engaged in teaching for a number of years, doing research work as time permitted. From 1907 he was almost entirely occupied with research with the United States Geological Survey till 1919 and with the Southern Pacific Company till 1921. His later publications were largely on geochemical studies of ore deposition and enrichment and on the geochemistry of waters, with special reference to the relations between natural waters and petroleum. His work on oil-field waters has been of much practical value in the production of oil.

AT the next meeting of the Columbia University chapter of the Sigma Xi, to be held in the new Chandler laboratories on February 16, Dr. H. C. Sherman will describe the research activities of the department of chemistry and Dr. Thomas B. Freas will explain the arrangement and equipment of the laboratories and at the conclusion of his talk will conduct a tour of inspection through the building.

THE Science League of America, Inc., has arranged with Station KFRC, one of the largest broadcasting stations on the Pacific Coast, to give a series of radio talks on evolution, by the president of the Science League, Maynard Shipley. These talks will be given on alternate Thursday afternoons, at 4 o'clock, the last

one having been on February 2 on "What Evolution means to you."

THE following series of lectures will be given at the New York Botanical Garden on Saturday afternoons at 3:30: February 4, "Important Tropical Fruits," Dr. H. A. Gleason; February 11, "Yellowstone Park's Trees, Flowers and Wonders," Dr. Henry R. Rose; February 25, "California Gardens," Miss Hilda Loines; March 3, "Rambles of a Naturalist among the Indians," Dr. Clyde Fisher; March 10, "Plant Hybrids: How they are produced and their Uses," Dr. A. B. Stout; March 17, "Botanizing in Trinidad," Dr. Tracy E. Hazen; March 24, "Florida," Dr. J. H. Barnhart, and March 31, "The Present Status of Evolution," Professor John M. Coulter.

UNIVERSITY AND EDUCATIONAL NOTES

A DONATION of $128,000 to Columbia University by the alumni of the College of Physicians and Surgeons to found a professorship in pathology at the medical school has been announced by Dr. Francis Carter Wood, as spokesman for the alumni. The money will be held in trust by the university until it reaches the sum of $200,000. The professorship will be called the Francis Delafield professorship, in honor of the founder of the pathology laboratory at the College of Physicians and Surgeons.

A GIFT of $1,650,000 for the erection of four residence halls for women students at Cornell University has been announced by Dr. Livingston Farrand. The name of the donor was withheld by request.

GROUND has been broken for the $750,000 institute of pathology at Western Reserve University. The building is a gift of the Rockefeller Foundation.

THE publication of the report of Charles F. Adams, treasurer of Harvard University, shows that the total endowment of Harvard, exclusive of land and buildings used for educational purposes, is now more than $82,000,000.

AT the University of New Hampshire, a separate graduate school under its own director has been established. Although no director has been officially chosen to head the new division of the state university, it has been intimated that Dr. Hermon Slobin, head of the department of mathematics, would fill the position.

DR. JAMES BUELL MUNN, assistant dean of Washington Square College of New York University, has been elected dean of the college. Dr. Munn will succeed Dr. John R. Turner, who recently was elected president of West Virginia University.

DRS. MARION ARTHUR BLANKENHORN and Roy Wesley Scott, now associate professors of medicine at Western Reserve University, have been promoted to the rank of clinical professor.

ASSOCIATE PROFESSOR J. B. REYNOLDS, of Lehigh University, has been promoted to a full professorship of mathematics and theoretical mechanics.

RALPH G. MEEDER, assistant professor of biology at Hamilton College, has been appointed instructor of biology at Wesleyan University, Connecticut.

PROFESSOR ARTHUR HUTCHINSON, F.R.S., professor of mineralogy and fellow of Pembroke College, has been elected master of Pembroke College in succession to the late Dr. W. S. Hadley.

PROFESSOR JAMES HENRY DIBLE has been appointed professor of pathology and bacteriology in the Welsh National School of Medicine.

DISCUSSION AND CORRESPONDENCE

ALEXANDROVSK BIOLOGICAL STATION

FOR biologists who have an interest in the low temperature relationships of organisms, probably no station is better situated than the one at Alexandrovsk at the mouth of the fjord by which the Kola River empties into the Arctic Sea. The faunal materials available at this station are brought into the arctic by the warm waters of the Gulf Stream. Many of the forms are in great abundance and easily obtainable. They have an interesting relationship to the fluctuating currents of the Gulf Stream. Owing to the changes in position of the four divisions of this current there is much fluctuation in the temperature, salinity, acidity and other ecological factors in this portion of the Arctic Sea.

The station is well established, having been in operation for twenty-eight years. The four major buildings are well situated immediately at the water's edge. Good housing space is available for 120 regular students who spend part of the summer months at Alexandrovsk, and for the 150–200 students who visit the station for a few days. There is usually a staff of 25–30 instructors, research workers, and specialists in residence. The director, Dr. G. A. Kluger, has made special arrangements for the entertainment of foreign scientists. Usually there are several persons in residence who can speak any of the principal languages.

The instruction at the station is excellent in comparative zoological anatomy. This phase of the work is under the direction of Dr. Nicholas Tanaseiichock with three assistants and three preparators. In the division of physiology Dr. Kreps was working on the effects of the acidity and salinity of the water

on the distribution of the organisms. Interesting work was in progress on intracellular digestion in medusae. In plant physiology Mlle. Vera Bersook was working on the rate of photosynthesis in algae.

The physiological work is greatly aided by a very complete hydrographic survey which has been in progress for several years. The station by motor ship sends expeditions on a triangular course of survey to 76° N. Lat. in February, May, August and November of each year.

Botanical instruction under Mlle. Titiana Voblikoff is concerned mainly with the classification and distribution of algae and lichens. There is a substation branch in the Hibini Mountains where collections of plants other than the arctic flora may be made.

Research is in progress through the whole year. The Arctic does not freeze in this region, owing to the warm waters of the Gulf Stream and owing to the action of a 13-foot tide. The main portion of the instructional work is given to three parties of students, each party spending five or six weeks in residence at Alexandrovsk.

The station publishes a series of reports in addition to journal articles. These may be had in exchange.

R. B. HARVEY

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THE ETIOLOGY OF EUROPEAN FOUL-BROOD OF BEES

THE attention of the writer has been directed to a communication from Denis R. A. Wharton appearing in SCIENCE, November 11, 1927, similar to one published in *Nature*, August 27, 1927, dealing with the cause of the disease of bee larvae commonly known as European Foul-brood, and the possible rôle of *B. alvei* (Cheshire and Cheyne) as an etiological factor. The article in question is based on data obtained, in part, by Mr. Wharton while temporary assistant under the writer's direction in the Division of Bacteriology, Central Experimental Farm, Ottawa, the publication being unauthorized, and, in the opinion of the writer, somewhat premature, particularly in view of the desirability of a thorough preliminary verification of the results obtained.

The organism isolated from diseased brood, which in pure culture was found to be capable of transmitting the disease, appeared to be closely related to, if not identical with, *Streptococcus apis* described by Maassen[1] but capable of considerable morphological variation showing types which are impossible to distinguish microscopically from what is commonly called *B. pluton* (White)[2] which is usually stated to be the exciting cause of the disease. The claim of White, however, may be said to be based on indirect evidence, on the basis of microscopical and inoculation tests with impure cultures, *B. pluton* apparently not having been obtained in pure culture. The similarity of certain stages of *Str. apis* in pure culture with the appearance of *B. pluton* in diseased material raises doubts as to whether the latter can be said to exist at all.

In obtaining the organism in pure culture from the comb containing larvae dead of foul-brood, a preliminary enrichment medium appears essential. Our most recent experiments have shown the most suitable substrate yet employed to be one containing peptone 1 per cent., K_2HPO_4 0.05 per cent., honey 1 per cent., yeast 1 per cent. and agar 0.15 per cent., slightly acid (pH = 6.2 approx.) A preponderance of the *"pluton"* form over *B. alvei* or other "secondary invaders" in the raw material is desirable if the coccus form is to be readily established. After two or three transfers the organism may be readily obtained in pure culture by regular plating methods.

Respecting the rôle played by *B. alvei*, experiments on the life-cycle of this organism are still in progress. Results so far obtained indicate that *B. alvei* is to be regarded as more than a secondary invader as is now usually stated. Depending on the nature of the substrate, upon the period and temperature of incubation, this organism exhibits a pronounced polymorphism which indicates that the typical rod forms and endospores most commonly encountered are but stages in the life history of the organism. The development of coccoid forms of *B. alvei* is particularly pertinent to the question of the etiology of European Foul-brood. Recent experiments were made with a culture of *B. alvei* which had been kept for over two years with occasional transfers on nutrient agar and nutrient dextrose agar. On these media as well as on solid substrates containing yeast, endospore formation is prompt, and further morphological changes are seldom. On a medium composed of peptone 1 per cent., K_2HPO_4 0.05 per cent., dextrose 0.5 per cent., saccharose 0.5 per cent., agar 1.5 per cent. (pH = 6.8), the type of growth is very different, being more transparent in character and endospore formation much lessened, being even absent on repeated transfers. After establishment of *B. alvei* on this substrate, subsequent plate cultures kept at room temperature for 3 to 5 weeks have repeatedly given rise to coccoid forms which in morphology and group

[1] Maassen, A. "Zur Aetiologie der sogenannten Faulbrut der Honigbienen." *Arb. aus d. Kaiserl. biol. Anst. f. Land. u. Forstw.* Bd. VI, Heft. 1, 53–70. 1908.

[2] White, G. F. "The cause of European Foul-brood." *U. S. D. A. Bur. Ent. Circ.* 157. 1912.

arrangement can not be distinguished microscopically from the forms which were found to be capable of transmitting the disease. So far attempts to stabilize this coccoid form of *B. alvei* have been unsuccessful, its separation by replating having resulted either in a return to the original rod type or a failure to grow on the medium employed. These difficulties in connection with the stabilization of new forms have been already emphasized by Löhnis and Smith.[3] These authors have shown the possibility of stabilizing coccoid cells from *Azotobacter,* while Cunningham and Jenkins[4] have obtained a coccus from cultures of *B. amylobacter* (A. M. et. Bredemann). That a similar stabilization of a coccoid form of *B. alvei* is feasible, is reasonable to presume, and its accomplishment would lend support to the hypothesis regarding the identity of *B. alvei* with the organism responsible for the infection in foul-brood, and furnish interesting light regarding the relationship of developmental phases of pathogenic bacteria to virulence. With all work concerned with etiology and pleomorphism, however, too much emphasis can not be laid upon the necessity for repeated confirmation of results. The writer would have preferred to withhold even this preliminary communication which is given reluctantly in view of the outlined circumstances.

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CONCERNING MAN'S ANTIQUITY AT FREDERICK, OKLAHOMA

AMONG the several recent reports of evidences of Pleistocene man in America, the case of Frederick, Oklahoma, must be received with caution. In 1926 the owner of a fossil-bearing gravel pit at this place unearthed several artifacts. The site was first examined and reported by J. D. Figgins, H. J. Cook and O. P. Hay,[1] and later by C. N. Gould, C. E. Decker and the writer.

The gravel pit has been sunk into a stratum of gravel and sand which caps a ridge a half mile wide and several miles in length. The stratum is from ten to twenty-five feet deep and lies on beds of Permian age. The ridge is the highest point for some miles around, the red beds falling away to the Red River. All observers are agreed that the gravel bed is of Pleistocene age; the presumption being that it was deposited in a valley bottom, subsequent erosion of the surrounding areas having left it in its present high position.

The artifacts are two arrowheads or blades and five possible metates or mealing slabs. According to Mr. Holloman, the owner, one blade was from the very bottom of the gravel, he having picked it up from loose material at the foot of the pit face as it was torn down by workmen. The second was at a somewhat higher level, four to eight feet. Mr. Holloman stated that he scratched this artifact from the face of the pit with his fingers. The slabs, identified as metates by Mr. Figgins, were taken from a level of a foot or two above the blades. All observers are agreed on the honesty of Mr. Holloman's representations.

Figgins, Cook and Hay concluded that the human artifacts are original constituents of this Pleistocene gravel bed as it was first laid down. Before this verdict becomes generally accepted, I should like to broach several problems.

No scientific man has seen the gravels in the immediate vicinity of the spot where the finds were made. These were all found within a short distance of one another, near the center of the gravel pit which now extends over several acres. We do not know the original position of the surface at this point with respect to the artifacts. The deposit is considerably eroded. There is the possibility that these artifacts lay on the surface of a depression, were subsequently covered by wash, and have only a specious claim to the antiquity of the near-by fossils.

As against this possibility is the fact that I was told that no artifacts have been found on the surface in the vicinity. On the other hand, it is quite possible that they may yet be found. The ridge presents the only body of suitable material for flaking blades for miles around and at the same time affords a wide view of the surrounding country.

The artifacts themselves are equivocal. The blades are clearly artifacts, resembling modern Indian forms, but the metates are questionable. It is difficult to decide from Mr. Figgins' illustrations whether the slabs were fabricated, and I have not seen the originals. They may be water-worn boulders. While at the time Mr. Figgins wrote that no other stones of a similar nature had been found, our party saw several slabs, clearly water-worn, which suggests the possibility that some of them had been selected as metates because of their close resemblance to such forms.

[3] Löhnis, F., and Smith, N. R. "Studies upon the lifecycles of the bacteria—Part II: Life history of Azotobacter." *Jour. Agr. Res.* 23, 401–432. 1923.

[4] Cunningham, A., and Jenkins, H. "Studies on *Bacillus amylobacter* A. M. et Bredemann." *Jour. Agr. Sci.* 17, 109–117. 1927.

[1] J. D. Figgins, "The Antiquity of Man in America" (Natural History, 27, 1927, 229–239). Harold J. Cook, "New Geological and Paleontological Evidence bearing on the Antiquity of Mankind in America" (*loc. cit.*, 240–247). Oliver P. Hay, "Early Man in America" (*Science News-Letter*, 12, 1927, 215–216).

More important than these conjectures, which are at best only possibilities, is the incongruity of the find with all we know of man's cultural history.

First with respect to the metates; among living peoples these are in use only by those who are cereal-raisers or who are in contact with them. For example, in North America grinding slabs are used only by the corn-raising Southwestern Indians and their seed-gathering neighbors of the Basin-Plateau region. Indeed the use of the metate may not be of remote date even in this area, and all Americanists are agreed that cereal-raising is not one of the original constituents of Indian culture. In the Old World also cultivation is a Neolithic art, that is, of geologically Recent provenience.

The blades are likewise of European Neolithic type, or at best of Solutrean technique (from the middle or close to the fourth glaciation).

Yet Dr. Hay has it that this deposit is of early Pleistocene age. The fossil animals include "a primitive elephant, a mastodon, two species of camels, two species of ground-sloths, a glyptodon and three or four species of horses, one very large, one pony-like. . . . As to the animals, I hold that they are characteristic of the first interglacial stage (the Aftonian) of the Pleistocene."

If Dr. Hay is right, and I have no reason to doubt his identification, we are confronted by an unusual situation. Artifacts which would be identified by an archeologist as Recent (or terminal Pleistocene) are held to be of the same age as an early Pleistocene fauna. This incongruity seems not to have occurred to Dr. Hay.

Is there any warrant to support this from what we know of the course of human events elsewhere? I think not. The earliest definitely human remains from the Old World (*H. heidelbergensis*) date from the second interglacial or the first. The Frederick deposit may antedate this. The earliest human artifacts (Chellean or Pre-Chellean) date from the middle or close of the third interglacial. These are quite roughly made in contrast to the well chipped Frederick blades. The zoological evidence conforms. Most authorities are agreed on man's anthropoid ancestry. The anthropoids are Old World forms; there are no known anthropoid prototypes of man in America.[2]

It seems to me that the onus of proof rests with those who hold that Neolithic implements are congruous with an Aftonian age. I am doubtful that the mass of cultural and zoological evidence to the contrary now available will be set at naught.

LESLIE SPIER
UNIVERSITY OF OKLAHOMA

[2] The case of *Hesperopithecus*, a single tooth of Tertiary age from Nebraska, seems disposed of by W. K. Gregory's recent determination of it as pertaining to an extinct peccary (SCIENCE, n.s., 66, 579–581).

"EXIT THE TENTAMEN, BUT . . ." WHAT?

UNDER the above caption, minus the last word, my esteemed friend, Mr. Wm. T. M. Forbes, in the issue of SCIENCE for October 28, 1927, undertook to reply to an article from my pen published in the same journal, July 1, 1927, entitled "Exit Hübner's Tentamen." Mr. Forbes addresses numerous questions to me. At one point he says: "What would Dr. Holland do about it?" To all of his numerous queries I shall give appropriate answers elsewhere in a journal more strictly devoted to the technical nomenclature of entomology, and shall in that article show how greatly Mr. Forbes, and others, who hold with him, have misunderstood the writings of Hübner, and his tentative system of classification. There is only one point upon which I wish to touch in this brief paper.

Mr. Forbes at the end of his paper says: "In bringing in the *Verzeichniss*, Dr. Holland does not mention that ten years had intervened and that in the meantime Hübner had used all the Tentamen names of butterflies as generic (as the first names of binomials) also many of the moths. This fact completely invalidates his argument."

Passing by the implication that I was making an "argument" in a matter which in my judgment is not open to argument, and was simply stating obvious truths, this allegation of Mr. Forbes awoke my utter astonishment. I am familiar with every page and line which Hübner gave to the world. Mr. Forbes's statement seemed to me most amazing. Accordingly I wrote to him inquiring upon what he based his sweeping statement that from 1806 to 1816 Hübner had used "binomials" in his nomenclature of the butterflies. Mr. Forbes has kindly replied to my inquiry and informs me that he based his assertion upon the legends of the plates in Vol. I of the *Sammlung exotischer Schmetterlinge*. Mr. Forbes's answer still more amazes me. Any one, who takes the trouble to look at these plates from a corner of one eye, can instantly see that the legends are all *trinomial*, and not *binomial*, as Mr. Forbes says. Mr. Forbes is under an illusion. *Three* is *not* equal to *two*, as *twice four* is not equal to *five*. Hübner in the legends of these plates was consistently true to the "System" he had adopted. On these plates he gives 1, the name of the *Stirps;* 2, the name of the *familia;* 3, the name of the *Gattung* (species). Not once does he employ a generic name, either in his sense, or ours. Mr. Forbes is wholly in error.

As Mr. Forbes's premise is false, and contrary to facts, his conclusion is equally false. His "argument" involves the logical error of *petitio principii*. It is

not true that Hübner used "binomials" during the period mentioned by Mr. Forbes, and it can only be by sophistry, which flies in the face of Hübner's own usage and explicit and oft-repeated statements, that it can be made to even seem that he used "binomials" in the period indicated. He came to use binomials at a later date, and finally toward the end of his life adopted the "binomial system of nomenclature," as we know it to-day. The legends of the plates in Vol. I of the *Sammlung exotischer Schmetterlinge* are *not* binomial, they are *absolutely* trinomial. I squarely take issue with Mr. Forbes on this point.

My motive for writing the foregoing lines is to simply let any reader of SCIENCE, who may have read my article of July 1 and Mr. Forbes's reply, understand that I am in thorough disagreement with him. I do not wish silence on my part in these columns to be construed as assent.

W. J. HOLLAND
CARNEGIE MUSEUM

VISIBLE RADIATION FROM EXCITED NERVE FIBER AGAIN

THE phenomenon of the "Reddish Blue Arcs and the Reddish Blue Glow of the Retina" is a very remarkable one—especially when it is exhibited (as I exhibit it) in a dark room before a whole audience at once. All are agreed that one is seeing entoptically certain optic nerve fibers on the surface of the retina —but why are they visible? I have given reasons for believing that they are emitting physical light—and this has required no "violent efforts of the imagination," as Dr. Davis[1] supposes that it has done—one has only to remember that nerve, when excited, gives out heat, and that heat is, objectively, the same thing as light. It happens that a physicist has just stated this explicitly: "The experimental evidence for thinking that light is a form of energy and *that radiant heat is of exactly the same nature as light* is overwhelming."[2] (Italics mine.) But may the cause be (Gertz) a secondary stimulation of some organ-fibers, ganglia, bipolar cells, or rods and cones—by means of action currents? There is a residual image, so nothing but rods or cones can be concerned—they alone contain the highly specific light-sensitive substance which furnishes a residual image. An electric current sent in from the outside gives visual sensations but with no residual image; "this does not prove, however," says Dr. Davis, "that an electrical disturbance *localized in the retina* (italics his) might not stimulate the photosensory mechanism directly." Now a current from the outside might conceivably have attacked the optic nerve only after it has left the eyeball, but that it actually runs along the fibers on the surface of the retina is proved by the fact that structural details of the retina are marked out by it—for instance, at certain intensities the blind spot will be seen to be of a different color from the rest of the field. Since this is the case, it is inconceivable that an action current generated *within* the nerve fiber should play any different rôle from one that comes into it from a battery on the outside. It follows that nothing but physical light attacks the photosensory mechanism.

My theory has now been beautifully confirmed by Deane B. Judd, of the Bureau of Standards (*American Journal of Psychology*, October, 1927).

CHRISTINE LADD-FRANKLIN

[1] SCIENCE, 1928, LXVII, 69.

[2] Crew, Henry, 1927, "General Physics," 319–320.

QUOTATIONS

GENESIS AND EVOLUTION

THERE will be no more monkeying in the public schools with the Mosaic account of creation as recorded in the book of Genesis, if Representative Hobbs's bill to prohibit it finds favor with his fellow members of the General Assembly and is approved by the Governor. Mr. Hobbs, who is the accredited representative of the sovereign legislative district composed of Wolf and Powell Counties, has introduced a bill to prohibit the teaching in the public schools of the state any theory of evolution that conflicts with his understanding of the sacred texts of Holy Writ.

Statesman Hobbs has eight children, whose simple faith in the Hebraic account of creation he would protect with the strong arm of the law. Many earnest, honest sticklers for the letter of the law will approve and applaud this zealous guarding by the Wolf-Powell statesman of the faith once delivered to the saints. Why should the great Commonwealth of Kentucky trail behind progressive states like Tennessee and Texas in this matter of protecting its youth against this threatening heresy? Was not the Grecian Socrates put to death for corrupting the faith of the youth in his time, respecting the virtues of the gods? Was not Galileo severely punished by the Hobbs law of his age for contradicting the Biblical teaching about the solar system?

Representative Hobbs serves well his state in seeking to call a halt on these venturesome modern school teachers. They have already poisoned the minds of a mighty multitude with the false doctrines that the earth is round, that the planets revolve around the sun, that this earth instead of being the sum and center of the universe is but a sand grain on the limitless shores of creation and, instead of being only six thousand years old, has been revolving through space for

untold ages. What about these idle fellows who spend their nights, not in honest sleep, but in peering through great telescopes into the starry heavens, or instead of reading the story of creation, so beautifully told in the book of Genesis, go reading the riddle of the rocks in a vain effort to controvert Moses' account of the beginning of things?

This revolutionary evolution theory is gaining alarming headway, and unless something is done about it right away there is no telling what may happen. And popular education is doing it. Woodrow Wilson, the greatest educator of his time, when asked his opinion of evolution said: "I take it no educated man questions the established fact of organic evolution." The schools and universities are to blame for the spread of this dangerous doctrine, and if statesman Hobbs would insure the rising generation against this corrupting teaching he should introduce a bill abolishing all public and private schools. The uneducated man accepts what he has been told by mother and the preacher; asking no questions. But as soon as the child appears in school, he begins to ask a reason for things. Oh, for a return of the simple faith in witches and ghosts and horse shoes and rabbit feet, a flat earth and a revolving sun, etc., and no questions asked. Lawmaker Hobbs is Kentucky's hope for this happy return of the good old days, but, alas! it is to be feared that he is casting his pearl before swine in that sceptic bunch at Frankfort.—*Kentucky Republican.*

SEPARATIONS BY THE IONIC MIGRATION METHOD

THE development of the ionic migration method for effecting difficult separations has been described in a number of articles appearing in the *Proceedings of the National Academy of Sciences*[1] and in the *Journal of the American Chemical Society*.[2] This series of investigations, carried out at Columbia University between 1920 and 1926 and continued at New York University since the latter date, has now given results of interest in several quite diverse fields. The presentation of an informal summary and the correlation of the results obtained are the purposes of this paper.

The work was started as an attempt to devise a practicable method for the separation of isotopes. Other investigators had succeeded in obtaining, at best, only a very slight degree of separation of isotopic elements into their various atomic species after heroic expenditures of time and labor by other methods, and it appeared that there did exist the possibility here of obtaining a quick and decisive result. The situation with regard to ionic mobility may be explained very briefly. A long-standing controversy has been waged on this property; one school insisting that ionic mobility is fundamentally dependent upon ionic volume, another being equally confident that it is fundamentally dependent upon ionic mass. The results available in the literature for homologous series of organic anions and cations have been utilized by both parties to give their respective points; but, since we have no definite knowledge as to what amount of solvent accompanies any ion in its journey towards an electrode and since it is the *total mass* or *total volume* of the ion and of its accompanying solvent envelope which must be taken into account, such data obviously offer us no means for definitely determining the problem.

The discovery that isotopes possess *equal atomic volumes,* made by Soddy and Richards in 1914,[3] first put us in a position to impose a crucial test, for isotopic ions necessarily *differ in mass.* If mass is influential, therefore, it should be possible to obtain a separation of isotopes by taking advantage of the fact that the lighter ion will migrate more rapidly than the heavier. This idea of an "isotopic race," however, can not be carried out experimentally as simply as it might seem at first sight. Ions do not compete under the influence of the electric current in the manner of a track meet, unless we extend our experiences to include a continuous relay race. We can not start all of our ions at one point and obtain a separation by noting when those of a certain species have passed a given goal, for there must be maintained a steady supply all the way from one electrode to another in order for the current to pass, and it will not help us much if a faster ion hurries ahead of its slower neighbor, since it will merely find itself in the company of other slower ions which happened to start a little in advance. By a modification of the experimental procedure, nevertheless, our "isotopic race" may be converted into a "parade" which can be suitably regulated.

The apparatus used is shown in the accompanying diagram, and its applicability may be illustrated by a condensed description of the technique employed in the case of chlorine.

An agar-agar gel A containing sodium chloride is inserted as a short middle section in a long horizontal tube of pyrex glass, one and a half inches in internal diameter. On one side of the chloride gel is added a gel B containing sodium hydroxide; on the other side a gel C containing sodium acetate. The ends of the tube

[1] *Proc. Nat. Acad. Sci.*, 9, 75, 1923; 10, 458, 1924; 11, 393, 1925.

[2] *Jour. Amer. Chem. Soc.*, 48, 2619 and 3114, 1926.

[3] Aston, "Isotopes," 17, 1922 (Arnold and Co.).

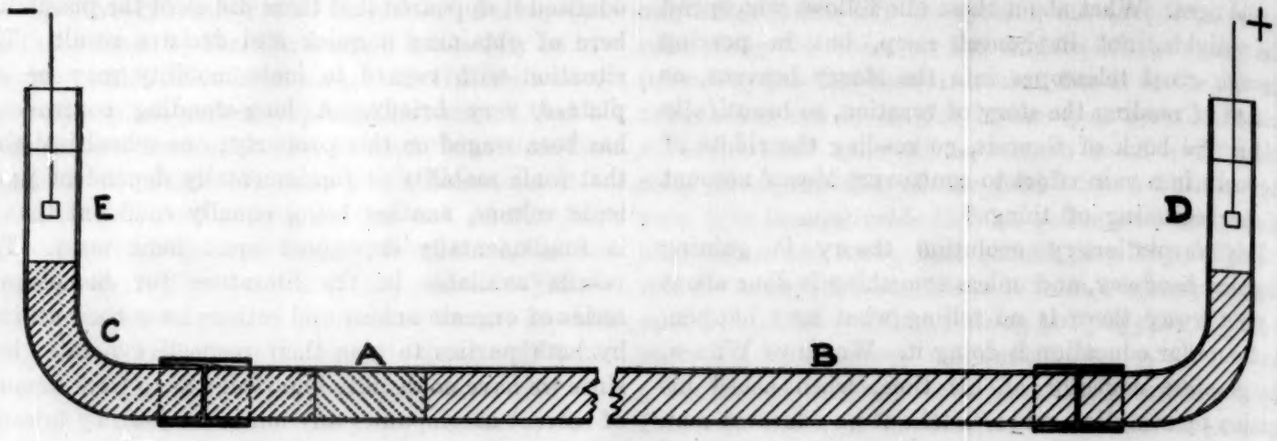

FIG. 1

are connected with right-angled pyrex bends of the same diameter, and the gels continue well up into these bends, as in the diagram. Above the hydroxide gel, after it has set, is poured concentrated sodium hydroxide solution D, and above the acetate gel a solution E of sodium acetate in concentrated acetic acid. Platinum electrodes are placed in these two solutions, and a current is passed through the tube, the electrode in D being made the anode and the electrode in E the cathode. The heating effect of the current upon the gel may be minimized by submerging the tube in a long trough filled with running tap-water.

At the beginning of the run, the boundary surfaces between the various sections of the gel are perfectly sharp. When the current is turned on, the boundaries move toward the anode. Inasmuch as there is a faster-moving ion in front of the chloride ion, and a slower-moving ion behind it, admixture of the salts is absolutely prohibited and the boundaries remain distinct throughout the whole experiment. In order to maintain the width of the chloride section approximately constant, it is well to arrange the concentrations of the various salts in their respective gels in accordance with the transference numbers of their anions. Even if this is not done, however, the boundary concentrations soon automatically adjust themselves to the required ratios. Care must be taken that the solution around the cathode always contains sufficient excess of acetic acid to neutralize the sodium hydroxide that is there formed.

The rate at which the boundaries move depends upon the potential drop between the electrodes, the length of the tube, and the concentrations of the solutions. In actual practice, the horizontal tube is made up of three three-foot sections, connected by rubber bands, and the current is regulated (100 to 500 volts) so that the boundaries advance about 12 to 18 inches a day. When the front chloride boundary has almost reached the end of the tube, the apparatus is taken apart. The two rear sections are discarded, two new sections filled with hydroxide gel are inserted in front of the chloride, and new bends are fitted on as before. The chloride ions are now forced to migrate into these two new sections, and the whole procedure is repeated until they have progressed through about 100 feet of the gel. The chloride gel is then removed from the tube and immediately cut up into strips about 1 cm. in width.

If, now, the isotopic chloride ions with atomic masses 35 and 37, respectively, possess significantly different mobilities, the front segments of the gel will contain only the faster-moving and the rear segments only the slower-moving isotope. Preliminary experiments in which a mixture of two sodium salts with anions of known mobilities was substituted for the middle sodium chloride section fully demonstrated this point. Thus when a mixture of sodium iodide and sodium thiocyanate was employed and the boundary was moved only a few feet, the front segments were found to contain only sodium iodide and the rear segments only sodium thiocyanate. The observed lag of the slower ion was almost exactly equal to that calculated from the difference in mobilities. In this particular case, the difference is approximately 16 per cent. In subsequent experiments this difference was narrowed by choosing other suitable pairs of ions; *e.g.*, barium and calcium, barium and strontium, and iodide and chloride. The differences in mobilities are here reduced to 8 per cent., 5 per cent., and 1 per cent., respectively, and the results obtained showed that the method could be depended upon to provide a very considerable degree of separation even at the lowest limit tested.

It was highly disappointing, therefore, to be forced to admit from the results of all our experiments with isotopic ions that no significant separation could ever be detected. The only conclusion that can logically be drawn is that the mobilities of isotopic ions are well within 1 per cent. of equality and that those workers are substantially justified who contend that volume is the decisive factor in determining ionic mobilities. More recent theoretical advances, it must be added, support this view, although the matter is still not absolutely settled.[4]

Experimental difficulties encountered in connection with this work on isotopes can not be discussed in full

[4] Jette, *Phil. Mag.*, 3, 58 (1927).

detail here, but mention may be made in passing, of two points. One was the impossibility of determining whether any separation was proceeding within a section except by interrupting its progress irretrievably through segmentation and analysis. In other words, there was no way of telling in advance if a run of 100 feet was any more advantageous than a run of 10 feet, or whether a run of 500 feet should be preferred. It was proposed by one assistant to solve this difficulty by incorporating with the material under examination a small amount of a substance containing a colored ion with a mobility *intermediate* between those of the two isotopes. The end of an experiment would then be automatically announced by the appearance of a thin colored strip in the center of the section, the gel in front of this strip containing only the faster isotope and the gel in the rear of it only the slower. Unfortunately, no colored ion with the properties required has yet been discovered. A second difficulty consisted in fixing the exact position of the boundaries during a run. Slight changes in the color of the agar-agar gel induced by the different salts present, or slight differences in the refractive index of the various sections were sometimes sufficiently good indications, but the much larger variations in their electrical resistance offered, in general, more dependable assistance. The approximate position of a boundary could frequently be determined merely by lifting the apparatus from the water trough for a few minutes, running the hand along the tube and noting the place at which a temperature gradient became evident. Finally, more exact information was obtained by fusing two short platinum wires through the glass at suitable points on the tubes and establishing the passage of a boundary past these points by noting when an abrupt change occurred in the electrical resistance of the gel between them.

Although all the work on isotopes, as has been stated, led to no successful separations, yet the positive results obtained in the test experiments on known mixtures did inspire the hope that the ionic migration method might, after all, prove of practical service in the separation of more familiar materials which are ordinarily obtained by the chemist in a pure state only with extreme difficulty. The most important instance of this type is furnished by the family of the rare earth metals. The group of elements known as the rare earths comprises the elements of atomic number 57 to 71 inclusive, and yttrium with atomic number 39. These elements are distinguished by such extraordinary alikeness in chemical and most physical properties, due to the identical arrangements of their two outer shells of electrons, that they actually approach isotopes in similarity. It is necessary, in practice, to take advantage of slight differences in solubility observed for corresponding salts and to resolve a given mixture into its components by a long series of fractional crystallizations or precipitations, ranging in number from several hundred to many thousand according to the elements present and the degree of purity desired. These operations are so laborious and time-consuming that chemically pure samples of individual rare earth compounds are practically unknown, save on the shelves of a few skilled workers in the field of atomic weights. The "rareness" of the rare earths is due not so much to the lack of abundance of their ores in nature as to the lack of a simple method for their separation.

Little is known of the relative mobilities of the rare earth cations in aqueous solution, but ionic volume and hydration variations within the group may be expected to cause differences in ionic mobilities which will, in most cases, exceed one per cent., so that a ready analysis of a given mixture into its pure components should be, in general, feasible. The experiments described below furnish, in fact, two instances of the successful separation of typical binary rare earth mixtures by the ionic migration method.

The first separation attempted was upon a mixture of yttrium and erbium, kindly furnished by Professor James, of the University of New Hampshire. Potassium was used as a preceding faster ion and trivalent chromium as a following slower ion. Not only could the position of the rear boundary be more conveniently followed in this particular case because of the color of the chromic solution, but it was also found possible to observe the actual progress of the separation within the rare earth section in a very simple way by means of a small direct-vision hand spectroscope. The majority of the rare earths give solutions with characteristic absorption spectra and, by noting the increase or decrease in intensity of the most prominent lines in various parts of a section, the experimenter could immediately detect any change in composition in the whole length of the section without interrupting the run. Here yttrium rapidly accumulated in the front half of the section and erbium was relegated to the rear. After a run of fourteen days, during which the boundaries moved two meters, an almost perfect separation had been effected.

The next mixture tested consisted of neodymium and praseodymium, two elements which are so nearly alike that their first differentiation by Otto von Welsbach still forms one of the triumphs of technique in this difficult field. Neodymium salts exhibit a purple solution in water, however, while praseodymium salts give a green solution. A beautiful crystal of neodymium nitrate and an equally fine specimen of praseodymium sulphate were secured from the

Chandler chemical museum of Columbia University and the careful work of several years was deranged in a few minutes by mixing these two salts to obtain a solution with an intermediate neutral tint. With this solution as a central section and with the same arrangement as in the preceding experiment, it required only a few days' migration to disclose the fact that the front portion of the section was becoming distinctly green and the rear portion purplish. Observation by means of the spectroscope simultaneously showed that the characteristic absorption lines of praseodymium were becoming more pronounced in the front section and fading out in the rear, with the opposite behavior for the neodymium. At the end of ten days, substantially complete separation had been accomplished.

Experiments with other mixtures of rare earths showed that, while complete separation could not be secured in every case, yet in most mixtures the mobilities of the ions were sufficiently divergent to compel a very rapid concentration of one particular component in the front or in the rear section. The method may, therefore, be considered as a general new method for obtaining pure samples of the rare earth elements with the expenditure of much less time and trouble than is required by the classical method of fractional crystallization. Professor Hopkins, of the University of Illinois, is, it may be mentioned, at present attempting to utilize the ionic migration method for the more rapid concentration of illinium (the last member of the rare earth family, discovered by him in 1925) from the neodymium and samarium residues in which minute traces of it exist.

Important industrial uses for the rare earth elements will undoubtedly be discovered as soon as more convenient means for their isolation are developed. Aluminum remained a chemical curiosity until this same end was achieved, and while the later members of the aluminum family may not duplicate the successful career of their brilliant brother, yet it would indeed be strange if nature had omitted to endow them, alone of all the elements, with no properties of service to mankind.

The success of the experiments with rare earths suggested that the method might be applicable to the separation of radium from barium. The concentration of radium from the barium residues of carnotite ores at present involves a very tedious series of fractional crystallizations, and, since it had already been found that barium could be separated from the other elements of the alkaline earth family by the method here under discussion, it appeared very probable that a similar separation from radium, the last member of this same family, could also be accomplished. Samples of barium residues containing known amounts of radium and of mesothorium (an isotope of radium) were obtained and, after a few days' migration, the sections were segmented and their radioactivity examined. It was found that the radioactive components of each mixture tested accumulated very rapidly in the front part of the section. The ease of the separation in this case is so striking as to suggest that the ionic migration method may come into technical use for the concentration of radium in barium residues.

An attempt to separate hafnium and zirconium did not lead to such conclusive results. Hafnium exists to the extent of several per cent. in all zirconium ores, and the similarity in properties is so pronounced that the actual discovery of hafnium was not definitely established until 1923. A sample of hafnium-rich zirconium oxide was kindly furnished us by Professor Hevesy. The elements were not amenable to separation by the ionic migration method in the form of positive ions, owing to hydrolysis, and only after considerable search was a suitable negative complex ion discovered in the form of a complex oxalate. After long migration, analysis showed a very slight accumulation of hafnium in the rear of the section, the mobilities of the complex anions being evidently so close together as to render a complete separation impracticable.

The results in an entirely different field have been of better promise. Many of the alkaloids particularly useful for medicinal purposes are derived from natural sources as mixtures of several individual members which can be separated by the ordinary methods of organic chemistry only with great difficulty. The alkaloids, however, are weak bases which form soluble hydrochlorides, and the mobilities of the cations of these salts are not identical. It should, consequently, be possible to obtain a pure sample of an especially valuable alkaloid from the mixture of similar materials with which it naturally occurs by use of the ionic migration method, and several preliminary experiments indicate that the method is indeed applicable in a majority of cases. Details will appear in a forthcoming communication.

Several other lines of research are also being followed. A very interesting case is the search for the missing element number 87. This element, from its position in the periodic system, should be a highly radioactive alkali metal. Just as radium is found associated with barium, so this missing element might be expected to occur in nature with other members of the alkali metal group. Now it is a very significant fact that the only elements of low atomic weight which exhibit radioactivity are potassium and rubidium. Two alternative explanations have been advanced, the first being the obvious suggestion that the radio-

activity is due to an infinitesimal trace of the missing alkali element, the second being that it is due to some unstable isotope of the commoner alkali metal. Without going into details, it may be stated that each alternative has, at present, more experimental facts in its disfavor than in its favor, and a third entirely novel explanation is by no means excluded. The present method appears to furnish some hope of advancing our solution of this question for if, by migration of a potassium or rubidium salt, it should be found that the radioactivity was concentrating in the very front or in the very rear of the section, then the isotopic explanation would presumably fall into the discard and further investigation might very conceivably justify the announcement of the discovery of the missing element.

The experiments thus far completed on potassium have not given any final results. It is true that no noticeable concentration of the radio-activity in either the front or the rear has been obtained, but this can quite plausibly be ascribed to the fact that the mobility of the unknown alkali metal ion is substantially the same in aqueous solution as that of potassium ion. The heavier members of the alkali metal group, indeed, all have ionic mobilities in water which are substantially identical within the limits of experimental error. In methyl alcohol solution, however, it has been shown that the mobilities differ very markedly and consequently it may be expected that the addition of some methyl alcohol to the aqueous gel will stagger the values sufficiently to enable a separation to be secured if any unknown alkali metal is present. This point is being tested experimentally at the present time.

Finally, the possibility is being investigated of the applicability of the method to the separation of organic isomers of various types. More complex biochemical problems, such as the concentration or isolation of specific proteins or even of vitamins from natural sources, are probably also open to attack by the ionic migration method, but the experimental technique in such cases has not yet been worked out in detail.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

DETERMINING SOIL MOISTURE RAPIDLY AND ACCURATELY BY METHYL ALCOHOL

IN a former communication (this Journal, April 5, 1927) the use of alcohol was proposed as a basis for a very rapid means of determining the moisture content of soils and possibly of other materials. The form of alcohol that was then suggested was ethyl alcohol. In order to ascertain whether there are other liquids that would be more satisfactory than ethyl alcohol, an investigation has been conducted in which a large number of liquids have been examined. It has been discovered that of all the liquids studied, methyl alcohol seems to be the most satisfactory, as it is the most powerful dehydrating agent. Indeed, this form of alcohol seems to be able to replace or reduce the moisture content of soils down to practically the absolutely dry basis, as will be readily seen from the data below.

	Percentage of water recovered from water added to oven dry soils. Per cent.
Sand	100.05
Loam	100.03
Clay	99.99
Muck	99.01
Silica gel	99.30

The directions for executing a moisture determination by methyl alcohol are the same as those already published (this Journal, April 15, 1927) for ethyl alcohol. There are five points in the procedure, however, that one must always pay special attention to. These are first, the soil must be stirred with a strong rod and reduced to the particle state so the alcohol can come into intimate contact with the entire soil mass. Second, the liquid must be always filtered. Third, great care must be taken to prevent evaporation. The latter can be mainly accomplished by keeping the funnel covered during filtering. Fourth, the temperature of the liquids should always be recorded and reduced to the same basis. And fifth, in calibrating the hydrometer, the specific gravity of the absolute alcohol should be taken under controlled temperature. Allowing the alcohol to stand in running tap-water, to attain the temperature of the latter is sufficient.

It is advisable to use absolute methyl alcohol.

In case of soils containing more than 50 per cent. of moisture, such as muck and peats, only about 10 grams of soil should be used to 50 cc of alcohol.

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A CONVENIENT METHOD OF MEASURING QUANTITIES OF CHLOROPLAST PIGMENTS

ALTHOUGH the photosynthetic mechanism in the leaves of plants has long attracted the attention of

workers in science, the relation between quantities of chloroplast pigments and growth has scarcely been touched. Apparently, the chief difficulty has been the lack of a rapid and fairly accurate method which did not require a great outlay of chemical equipment.

Willstätter and his coworkers devised a simple method of extracting and purifying these pigments, and estimated the quantities colorimetrically. They used solutions of potassium dichromate as color standards for carotin and xanthophyll, having previously evaluated the standards in terms of the pigment in question. The chlorophylls (a plus b) were estimated quantitatively by saponifying the chlorophylls with methyl alcoholic potash to form chlorophyllins. These solutions of chlorophyllins were taken up in water and then measured colorimetrically, using as standards, solutions made up from a known quantity of pure chlorophyll which had been similarly transformed to chlorophyllins. These colorimetric methods are not then measured colorimetrically, using as standards are not chemically stable and (2) because the tint of potassium dichromate solutions is not identical with that of carotinoid solutions, therefore, giving variable results.

Willstätter's method of extraction and separation of the chloroplast pigments has been given in detail by Stiles.[1] Recently Dr. F. M. Schertz, of the United States Department of Agriculture, has modified Willstätter's method, and kindly made the revised method available to the writer for certain investigations on the relations between chloroplast pigments and growth in maize. Dr. Schertz's method, which is simple and adequate for the study of problems of this nature, is now in the press.

The quantitative estimation of the pigments after extraction and separation has also been investigated by Schertz.[2, 3]. He finds the spectrophotometric analysis of solutions a more accurate method than the use of Lovibond slides in a colorimeter. However, the spectrophotometer is an expensive instrument and available to a very limited number of workers.

Since early in 1925 the writer has been using a method of estimating chloroplast pigments in solution which has given consistently good results, is simple, inexpensive and within the reach of the ordinary research laboratory. The amounts of the respective pigments are determined by comparing with artificial color standards of identical tint making use of a Duboscq colorimeter.

The chlorophylls (a plus b) were obtained in the form of aqueous solutions of the chlorophyllins (a plus b which are green by transmitted light. A color standard which matches the tint of the mixture of chlorophyllins obtained from maize was prepared by making 0.3 cc of a one half per cent. aqueous solution of Malachite Green and 11.2 cc of a one half per cent. aqueous solution of Napthol Yellow (Martius yellow) upto 5,500 cc with distilled water. The concentration of color in this standard is the equivalent of 10.706 milligrams of pure chlorophyll (supplied by Dr. Schertz) saponified to chlorophyllins and diluted with water to make 1 liter.

The carotin color standard was made by adding 3.4 cc of a one half per cent. aqueous solution of Napthol Yellow and 0.5 cc of a one half per cent. aqueous solution of Orange G. crystals to 1 liter of distilled water. The tint of this standard is identical with that of pure carotin dissolved in petrol ether and is the equivalent in concentration with carotin solutions containing 1.890 mgms of carotin per liter of solvent.

The xanthophyll color standard was made by adding 2.8 cc of a one half per cent. aqueous solution of napthol yellow to 1 liter of distilled water. The tint is identical with that of pure xanthophyll dissolved in petrol ether and is the equivalent in concentration of 1.537 mgms of xanthophyll per liter of solvent.

Evaluation of the carotinoids was accomplished by making readings of solutions of the pigments in the colorimeter in terms of their respective standards, and also making readings of the solutions in the König-Marten's spectrophotometer at the Bureau of Standards at Washington through the courtesy of that bureau and with the assistance of Dr. Schertz.

There appear to be several advantages in using these artificial color standards for quantitative estimation of the chloroplast pigments: (1) The materials and equipment are inexpensive and are therefore within the reach of a large number of workers in science. (2) The method is fairly accurate, because the tint of the standards is practically identical with that of the pigment solutions, and delicate readings may be made in the colorimeter by varying the volume of the solutions in question. (3) The method is rapid; readings may be made as soon as purification is complete, thus eliminating the large errors caused by decomposition of the pigments in manipulation. (4) The one half per cent. aqueous solutions of the dyes keep for many months (20 by test) without deterioration. 10 grams of each of the dyes, solutions of which have been evaluated in terms of the pigments, should be sufficient for a period of years.

[1] Stiles, Walter, "Photosynthesis. The assimilation of carbon by green plants," London, 1925.

[2] Schertz, F. M., "The quantitative determination of carotin by means of the spectrophotometer and the colorimeter," *Jour. Agr. Research* 26 (1923), p. 383.

[3] Schertz, F. M., "The quantitative determination of xanthophyll by means of the spectrophotometer and the colorimeter," *Jour. Agr. Research* 30 (1925), p. 253.

Different lots of the same dyes may vary in purity, nd therefore each new lot should be evaluated in rms of solutions of pigments of known concentra- ons. The color standards fade slowly when exposed light and should be made up fresh from the one half er cent. aqueous solutions every few weeks. The ne half per cent. solutions should be discarded if ey become turbid or if sediments appear.

Full details regarding the preparation and use of ese color standards, as well as the results of the udies on relations between chloroplast pigments and rowth of maize, will be published in the near future.

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SPECIAL ARTICLES

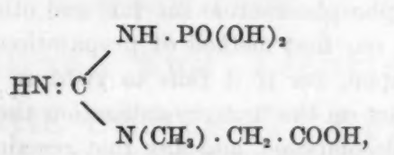
THE ISOLATION AND FUNCTION OF PHOSPHOCREATINE

I. ISOLATION

IN a previous communication[1] we have offered indirect proof of the presence in voluntary muscle of a compound containing one molecule each of creatine and phosphoric acid. The amount of this substance in muscle is considerable (0.4 to 0.5 per cent.); in fact it (and not free creatine) is the principal "extractive" as long as the muscle has not been stimulated or otherwise disturbed. During muscular contraction the compound undergoes hydrolysis, and the same change occurs outside the body under the influence of an enzyme in the muscle or of acid, whereas resynthesis takes place when fatigued muscle is permitted to recover.

At the time of our first report, the leading evidence for the existence of a creatine-phosphoric acid compound depended upon its separation from free creatine by precipitation with copper in very slightly alkaline solution. Under all the conditions enumerated above the precipitate so formed contains creatine and a peculiarly unstable form of phosphoric acid in equimolecular proportions, excepting when—in consequence of stimulation or some other cause—complete hydrolysis of the substance has occurred, and then the copper precipitate is free from both the named constituents. In view of the quantitative nature of the evidence, and of the variety of conditions under which the test has been applied, a different explanation of the results described is hardly possible, and we felt no hesitation therefore in stating that such a compound actually exists. The precise nature of the substance, however—in particular the question whether it contains anything besides creatine and phosphoric acid—can hardly be settled with certainty except by its isolation in the pure state.

Within a few days of the publication of the paper mentioned, we succeeded in isolating a barium salt in crystalline form, but the method of preparation was unsatisfactory and the yields were very poor. After many variations of the original procedure had been tried, the conclusion was finally forced upon us that the use of barium for this purpose is successful only when preceded by a series of preliminary separations (with other metals) in the course of which a large amount of material is lost. By using calcium in place of barium, however, most of the phosphocreatine in protein-free muscle filtrates can readily be separated, in a crystalline condition, from all the other organic phosphoric acid compounds present, but in order to remove these impurities without hydrolysis of the desired product it must be crystallized from alkaline solution. Under these circumstances the result is not a single substance. It contains both secondary and tertiary salts, and (partly because carbonate is present) the carbon content is too high. To obtain the pure secondary salt, having the composition required by theory, special measures must be taken, for this salt in aqueous solution is acid and therefore unstable. The final product crystallizes in spherulites, and has the composition $C_4H_8O_5N_3PCa.4H_2O$. The most probable structure of the new substance is hence the following:



and its most characteristic chemical property, *viz.*, marked instability in acid solution, is in fact characteristic also of the few other known compounds which contain the group $-NH.PO(OH)_2$. This is the first substance containing phosphorus attached to nitrogen to be isolated from natural sources, and the instability of the phosphamic group marks it as one of considerable biological importance, as will be seen in the next section. The details of preparation will be published elsewhere.

II. FUNCTION

In spite of much investigation, the function of creatine in muscle has remained as much a mystery as it was at the time of the discovery of this substance 97 years ago. Having found that most of the creatine in normal resting muscle is combined with phosphoric acid, and that the compound is destroyed during contraction at a rate which rivals that of glycogenolysis and lactic acid production, we naturally anticipated

[1] C. H. Fiske and Y. Subbarow, SCIENCE, Vol. 65 (403)—1927.

that some light might at last be thrown on this time-honored question. Among the possibilities which suggest themselves is a change in hydrogen ion concentration accompanying the hydrolysis of phosphocreatine, and either augmenting or opposing the increase in acidity associated with the formation of lactic acid. The determination of the direction and magnitude of this effect becomes therefore a matter of some consequence.

From experiments with a preparation of the crystalline calcium salt which we had in our possession several months ago it was evident that hydrolysis in slightly acid solution resulted in a very marked decrease in acidity. This was one of the preparations to which we have referred in the first section as being a mixture of two salts, containing too much carbon, consequently the presence of organic impurities which might account for the observed effect could not be excluded. Moreover, the existence of a special neutralizing mechanism has been denied on the ground that muscle acquires the same pH whether lactic acid is produced within it as a result of stimulation or whether the same amount of lactic acid is added artificially to a muscle suspension in which enzyme action has presumably been stopped.[2] For this reason, and because of the importance of the question in relation to the chain events occurring during muscular contraction, we regarded our observations as uncertain until they could be confirmed with material that was analytically pure. While engaged in collecting a fresh supply of phosphocreatine for this and other uses we found that our first method of preparation could not be relied upon, for if it fails to yield an essentially pure product on the first crystallization the substance is largely decomposed, and any that remains intact is less pure than before. The consequence is that the confirmation of our earlier results has been delayed still further through the necessity of developing an entirely new process free from this element of risk.

The second dissociation constant (k_2') of phosphocreatine, determined by the titration of a 0.005 M solution of the pure secondary calcium salt with acid, is about 2.5×10^{-5}, or roughly 250 times as great as the second constant of o-phosphoric acid at the same ionic strength. This result, which is presumably to be attributed to the "unmasking" of the carboxyl group, establishes the function of phosphocreatine in muscle—or one function, since there may be others—as that of neutralizing a considerable part of the lactic acid formed during muscular contraction.

The other dissociation constants have not been determined, but on the addition of alkali to a solution of the secondary salt no marked evidence of buffer action appears until well beyond the turning point of phenolphthalein. It follows that the third constant is much less than 10^{-7}, so in resting muscle,—which according to the most recent evidence[2] is practically neutral—phosphocreatine exists wholly as the secondary salt.

Calculations based on these facts show that the hydrolysis of phosprocreatine (taking an average figure of 0.45 per cent. for the amount in resting cat muscle) liberates sufficient base under optimum conditions (pH 6)[3] to neutralize the lactic acid formed up to a concentration of about 0.23 per cent.[4] Approximately half of this amount of lactic acid, moreover, can be neutralized at pH 7, *i.e.*, without the development of any acidity at all. Since the lactic acid maximum for complete fatigue, at least in isolated frog muscle, is 0.4–0.5 per cent. (or even more under special circumstances), it appears that this new mechanism is peculiarly designed for the neutralization of the lactic acid formed in muscular exercise of moderate intensity. Finally, it should be noted that the occurrence in contracting muscle of a reaction by which fixed base is set free necessarily detracts to some extent from the importance of protein[5] in the neutralizing process. The hydrolysis of phosphocreatine seems now to be the principal factor permitting contraction to take place to a limited extent without the appearance of fatigue, if it is true—as has been claimed[2]—that the main restriction on muscular performance is the accumulation of acid in the cells.[6]

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Y. Subbarow

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[2] O. Meyerhof and K. Lohmann, *Biochem. Z.*, Vol. 168 (128)—1926.

[3] *I.e.*, the maximum amount of base is released (in dilute solution) at pH 6, which is roughly the acidity of completely fatigued muscle.[2]

[4] This figure is necessarily a rough one, including as it does the supposed "physiological minimum" (0.06 per cent. lactic acid) for mammalian muscle (W. M. Fletcher, *J. Physiol.*, Vol. 47 (361)—1913; G. Embden, E. Schmitz, and P. Meincke, *Z. Physiol. Chem.*, Vol. 113 (10)—1921).

[5] O. Meyerhof, *Arch. ges. Physiol.*, Vol. 195 (22)—1922.

[6] The existence in muscle of a special device for neutralizing acid raises a number of interesting questions which can not be answered without further experimental data. For example, judging from some recent observations made by Meyerhof and Lohmann (Naturwissenschaften, Vol. 15 (670)—1927), the hydrolysis of phosphocreatine in brief periods of stimulation proceeds more rapidly than the production of lactic acid. This is difficult to reconcile with the prevailing view that contraction is a response to increased acidity, but further investigation may show that the inconsistency is only an apparent one.

SCIENCE NEWS

Science Service, Washington, D. C.

A SEISMOGRAPH TO RECORD MINOR EARTHQUAKES

A NEW seismograph that records the less violent tremblings of the earth's crust, undetectable by the human senses, is now installed and in operation at Stanford University. As a part of the fundamental plan for an intensive study of the California earthquake situation, this station has been established by the business men of San Francisco and Oakland as one of four, which are so located as to record the local shocks in the vicinity of that metropolitan center. The central station is at the University of California and the auxiliaries at Lick Observatory, Stanford University and the California Academy of Science in Golden Gate Park. The instruments and arrangement are patterned on the plan of observation inaugurated by the Carnegie Institution of Washington for southern California to keep track of the minute earthquakes that are constantly occurring and which indicate the development of strain that leads to the greater ones. Four little shocks were recorded recently at Stanford on the new instruments. There is no occasion for alarm, however, since this is merely the normal activity of the earth's crust, not only in California, but also in any region where earthquakes have occurred. Vibrations of the solid earth are as unknown as were those of the atmosphere before radio showed them up. Protection against earthquakes will not be achieved unless we secure a better understanding of their development during the long periods that elapse between severe shocks.

The seismograph installed at Stanford was placed on a ledge of rock that was selected because of its apparent solidity, but the first records showed an extraordinary number of microscopic vibrations, not exactly like those of earthquakes. They were most continuous on windy days and are attributed to a large oak tree which stands about fifty feet away from the instrument piers. The roots evidently extend into the crevices of the rocks, where they find water during the long dry season, and the swaying of the tree shakes the massive ledge of sandstone. The oak will probably have to be cut, to the regret of those who, because of its beauty, sought to include it in the Seismograph Park which has been set aside in perpetuity.

CORN WASTES

A BILLION dollars of new wealth for the corn belt, through the annual utilization of its two hundred million tons of corn stalks and twenty million tons of cobs, now wasted, is the promise of engineers and chemists to the American farmer.

How the greatest agricultural waste, corn stalks and cobs, can be made into some three hundred useful products is told in a report to the Engineering Foundation by Professor O. R. Sweeney, of Iowa State College. In a decade or two they will be utilized on a large scale, he predicted.

"Before the many products of promising usefulness could be made even on a small scale in the laboratory," Professor Sweeney said, "years had to be spent in patient, ingenious, fundamental researches to determine the exact chemical and physical natures of these raw materials and their constituents. Not only agricultural, but also industrial and economic problems had to be solved with the aid of engineering research, supplementing the work of the scientist. Much remains to be done.

"Iowa State College, in the midst of the corn belt, has been a leader in the attack. Knowledge being gotten in the cornfield will be useful also to growers of other grains, peanuts, flax and cotton, who have similar waste materials. Civilized men will be able to continue to feed and clothe the increasing populace and to supply many of their other wants by successful solution of just these problems.

"What does the laboratory offer to industry from these raw materials now wasted? Paper of several grades, papier maché, wallboard and other substitutes for building lumber, substitutes for hard woods used in furniture and finish, rayon, acetic acid, acetone, a sugar that can be used by diabetics, maple-sugar flavoring to be combined with cane- or beet-sugar to make 'maple-syrup,' oxalic acid, plastic materials, electrical and heat insulation and furfural.

"Furfural was a laboratory chemical not many years ago, scarce at $50 a pound. Now it is produced in large quantities at 14 cents. With increasing production, improved methods and development of co-products, even the latter price may be more than cut in half. Furfural is a fluid heavier than water, having many and various uses in plastics, dyes, paint removers, antiseptics, anesthetics, germicides, embalming fluids and motor fuels. It burns in lamps with a more brilliant flame than kerosene and has not the unpleasant odor of the latter.

"If the chemist and engineer and farmer can solve the economic problems, new industries may dot the prairies. Among these problems one of the foremost has been the cheap collection of the stalks and cobs to a few places where they will be subjected to the first steps toward becoming saleable commodities. Special machines have been devised for gathering up the cornstalks in the field, or for cutting the standing corn, husking the ears and shredding the stalks. Another problem is the safe and inexpensive storage of the raw materials throughout the year, in order that the industrial operations may be continuous.

"As contrasted with forests, which, once cut, are not quickly replaced, and commonly in America are not replaced at all, the corn wastes would be produced year after year in great quantities within the same areas. As nearby forests have been consumed, for example, the

saw mills and pulp mills have had to move to more and more remote locations from their markets.

"Lest the corn production should decrease, the fertility of the soil must be maintained. It has been learned that this can readily be done by growing soya beans as the 'rotation' crop. The soya bean is a strong nitrifier of the soil. After extracting the oil from the bean, the refuse, including the stalks and meal, can be plowed back into the soil. The income from the oil, which has many uses, will partially offset the lack of income from corn in the years of change of crop. Thus the cycle would become complete by the chemistry of nature, and the energy of the sun would be converted perennially to many uses of man.

"Depletion of forests and of mineral resources and advances in chemistry and engineering will have much to do with the measures of success which may be achieved in turning these agricultural wastes into wealth. At best, it will take much time, research and development.

"More than research, engineering, industrial development and financing will be required. Useful and valuable new commodities may be produced, but successful production at a fair price may not bring economic success. As has well been said: The fight for recognition for a new product is almost as hard to wage as is the fight for a new idea."

THE CORN BORER MENACE

THE corn borer, which has swept over the northeastern states and during the past season made its first serious inroads into the great mid-western corn belt, may lose its terror as it spreads westward into the less humid prairie regions. Researches by Professor E. N. Transeau and Professor H. C. Sampson, of the Ohio State University, indicate that the pest tends to accumulate in really destructive numbers mainly in areas of naturally high soil and atmospheric moisture, and that its presence in drier places is less likely to be a serious matter.

Professor Transeau's studies began in Ohio and Ontario, but were carried forward last summer by visits to the principal corn-raising regions of Europe, where the borer has been known for more than a century. In the analysis of the Ohio and Ontario data, it was discovered that the most serious borer infestation occurred in parts that were once covered by swamps and swamp forests. Fields that had been won from the former beech forests were also infested, but less seriously, and the areas that got off most easily were those that had once been covered by oak-hickory timber. The significant thing about this difference, Professor Transeau points out, is that the beech forest was a formation of relatively moist lands, whereas the oak-hickory was a dry type of forest.

In Europe, the Ohio botanist found that conditions bore out his preliminary observations in this country. The heaviest infestations were found in what were once swamp forest regions, while corn growing in drier and better drained hilly areas was much less troubled. In particular, he found that the great corn-growing areas of Rumania and southern Russia, which are naturally open grasslands instead of forests, are not greatly troubled by the borers, in spite of the fact that the farmers of these two countries probably take fewer clean-up precautions than do the corn growers of any other part of Europe.

Since the richest part of the American corn belt, reaching from central Illinois across Iowa into Nebraska, was originally a grassland, it is hoped that conditions here will be as unfavorable to the borer and as favorable to the corn as those of the European grasslands seem to be. It is true that the situation is not exactly parallel, for the long-grass prairies of Illinois and Iowa have no counterpart in southeastern Europe, whose grassy steppes are more like the mixed prairie and short-grass plains of Nebraska and Kansas. The long-grass prairies in part originated from sloughs and swamps, and in part developed on well drained uplands. The swamp prairie lands appear to be favorable to the corn borer. The upland long-grass prairies on the other hand fit into the series between the oak-hickory forest and the short-grass steppes or plains; and the relatively slight borer infestation of both regions gives rise to the hope that when the pest finally reaches the heart of the corn belt it will not everywhere have the disastrous effects on the principal American grain crop that were at first feared from its behavior in the vicinity of Lake Erie.

ULTRA-VIOLET RAYS AND MINERAL SALTS IN PLANTS

ULTRA-VIOLET rays, used to prevent the bone disease, rickets, in young children and animals by raising the calcium and phosphorus content of the blood, have a parallel effect on plants. This is indicated by the results of experiments by Herbert C. Beeskow, a graduate student at the University of Chicago.

Mr. Beeskow grew groups of soy bean plants in solutions of known mineral composition. He subjected different groups to ultra-violet radiation for varying periods of time, keeping other groups away from the rays as "controls." Then he dried the plants and analyzed them for calcium and phosphorus. In each case it was found that the irradiated plants had noticeably higher contents of these important minerals than the corresponding unrayed controls.

The effects of irradiation with ultra-violet light were not all beneficial to the plants. Soy beans grown in the greenhouse and subjected to direct ultra-violet raying for as short a period as one minute every other day showed a distinct reddening in the parts of the stem and leaves struck by the rays. This coloration increased with increases in dosage. In cases where the under side of the leaves was exposed to the rays the reddening action was much more in evidence.

Plants grown in darkness and subjected to the rays showed this red color much more distinctly than plants grown in daylight and permitted to become normally green. Heavy overdoses of the rays simply killed the plants.

THE VOLTAGE OF VACUUM TUBES

USING a radio vacuum tube backwards in order to reduce the voltage and increase the power at the same time is the trick described at the Institute of Radio Engineers.

In a paper by Frederick E. Terman, of Stanford University, California, it was stated that the plate and the grid of a tube could be made to interchange their functions.

In the ordinary vacuum tube, as used in the usual receiving set as an amplifier, the feeble electrical impulses that form the signals are fed into the grid. The electrons that travel across from the filament to the plate produce an electrical current, much larger than the current entering the tube, but varying in conformity with it. However, the outgoing current is also higher in voltage, as well as more powerful, than the incoming.

Mr. Terman has found, however, that the voltage can be reduced by interchanging the plate and grid. He feeds in the current to be amplified to the plate instead of the grid, and takes it out from the grid.

"It is relatively simple," he states, "to construct an inverted vacuum tube with wide clearances between the plate and the rest of the tube, so that potentials of hundreds of thousands of volts can be applied at the plate, while the effect of this high voltage stepped down in almost any desired ratio is obtained in a low potential circuit."

The chief use of the inverted tube, Mr. Terman stated, is in studying the waves formed by high voltage alternating currents, using an oscillograph. In this way, the current variations can be studied without consuming any appreciable amount of the current. No immediate use of the device in ordinary radio sets is foreseen.

RADIO RECEIVERS

SHEETS of metal such as iron, gold or platinum, so thin that ordinary type can be read with ease through them, may find use in radio and phonograph reproducers. Ordinary diaphragms for this purpose are so heavy that they dampen some of the overtones and so coarsen the sounds. These thin metal sheets are the result of research by Dr. Carl Mueller, of the Charlottenburg Laboratory, near Berlin. His method of preparing them is to electroplate the metal on the surface of some soluble substance, such as rocksalt, and then dissolve away the support. A ring of thicker metal can be used to support the films, of which two and a half million would have to be piled to make a stack an inch high.

Such films have been made of iron, nickel, gold, silver and platinum, and it is found that although the nickel is much less transparent to visible light than gold, it readily transmits the shorter ultra-violet rays. The films are very elastic, and will bulge out for as much as a tenth of their diameter without breaking. Another curious thing about them is their high electrical conductivity. Electric current is carried only along the surface of a wire, and as these are practically all surface, a strip of film containing no more metal than in a round wire one hundredth of a millimeter in diameter—scarcely visible to the naked eye—will carry enough current to light several lamps. If the same current were passed through the wire, it would be instantly melted.

ITEMS

SEEDLING trees of a species that represents the vegetation of Florida a hundred thousand years ago, during the glacial epoch, have been added to the collection in the New York Botanical Garden as the result of a scientific tour of the state by Dr. John K. Small. The trees, which are known as Torreya, or locally as Savern, belong to the botanical genus *Tumion*, and occur naturally in a small strip of territory along the east bank of the Appalachicola River, in the Florida Panhandle. They occur nowhere else in the world, though related species are found in California, Japan and China. They resemble yew trees in some ways, and can be cultivated under the same sort of climatic conditions that favor the yew. In addition to the Torreya seedlings, Dr. Small also obtained a collection of native Florida iris species, which are being carried through the winter in the garden of Mrs. A. C. James at Coconut Grove, Florida. A part of this collection will be brought north to the New York Botanical Garden in the spring.

THE largest telescope in Italy, with a mirror 40 inches in diameter, is now in use at the Merate Observatory, in the foothills of the Alps. Ordered in 1923, when the dust and smoke of Milan made it necessary for the observatory to move to a better location, the new instrument embodies all the latest improvements. It is a reflecting telescope, in which the 40-inch concave mirror takes the place of the convex lens in the more familiar type of telescope. The moving parts of the telescope weigh over 18 tons, yet so perfectly are they balanced that a one half horsepower motor is adequate for turning the instrument to follow the stars across the sky. The instrument was built by the Carl Zeiss Optical Works, in Jena, Germany.

"A LOVE of luxury is everywhere in the world tending to produce fewer marriages and fewer births," according to Dr. Charles V. Chapin, who for almost 40 years has supervised the collection of the vital statistics of Providence, R. I. The city's birth rate last year was the lowest since records were first kept. "In most of the advanced countries of Europe for several years the tendency of both marriages and births has been downward. I believe this is generally due to the fact that people don't feel they can afford to either marry or have children. They would rather have fur coats and automobiles." Of the children born here last year, 3,089 were boys and 2,049 girls.

A SELF-WINDING clock, run by what is virtually a glycerin thermometer, has been invented by a Swiss engineer, Karl Heinrich Meier. It utilizes the energy captured by the daily fluctuations in temperature to raise the weights that drive its mechanism, and it is stated that one of the clocks has been kept going for a year on a daily range of not more than eight degrees Fahrenheit. The essential mechanism consists of a long coiled tube filled with glycerin, connected with a cylinder into which a piston is fitted. When the glycerin is warmed and expands, it forces out the piston, which in turn lifts the clock weight. It is expected that this device will be especially useful in operating outdoor clocks in public places. The types now in common use are usually electrically driven and are therefore expensive to install, besides requiring frequent attention.